Manitoba
Energy and Mines
Minerals Division

Report of Field Activities 1989

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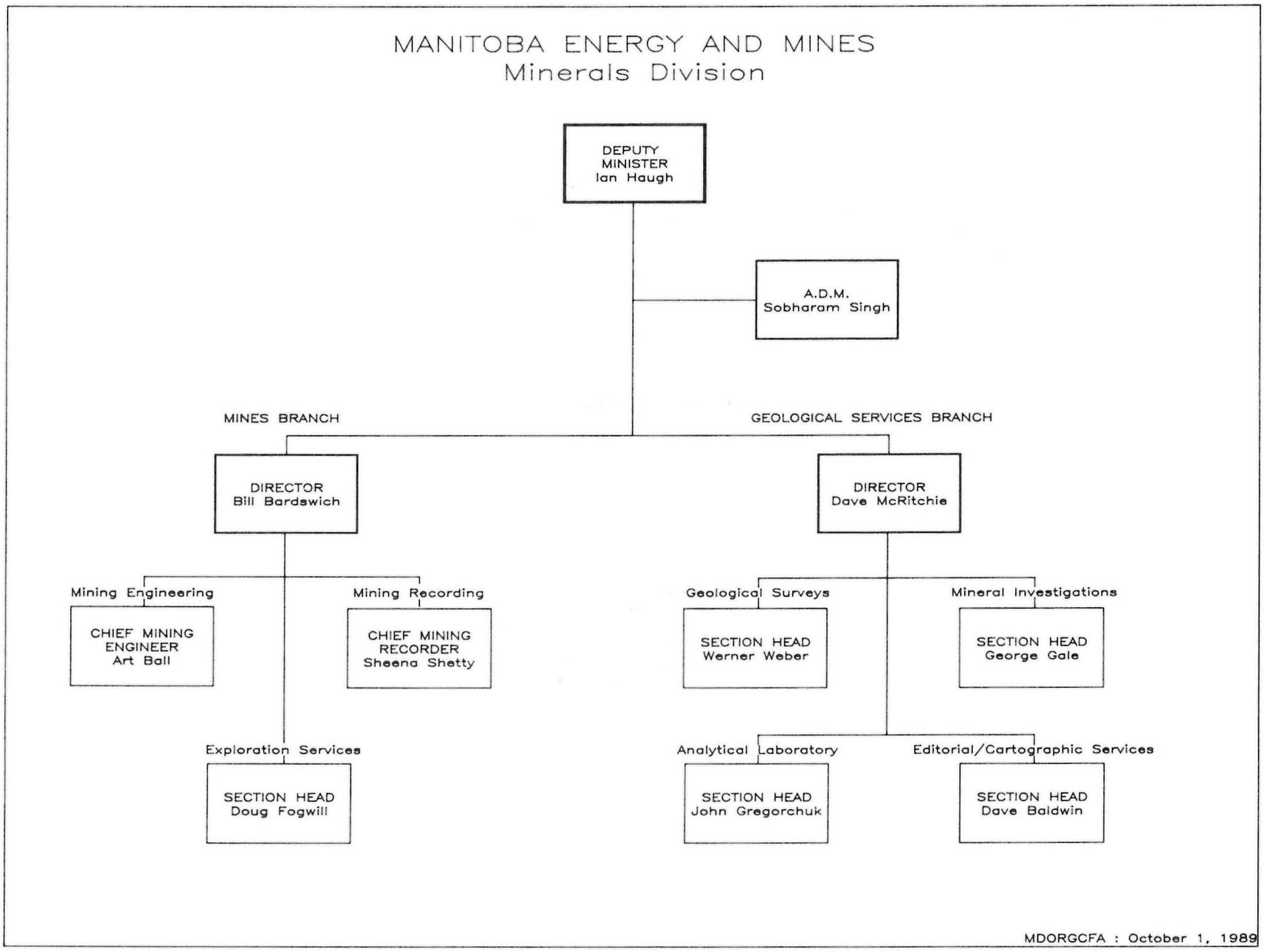
REPORT OF FIELD ACTIVITIES 1989

1989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MDORGCFA : October 1, 1989

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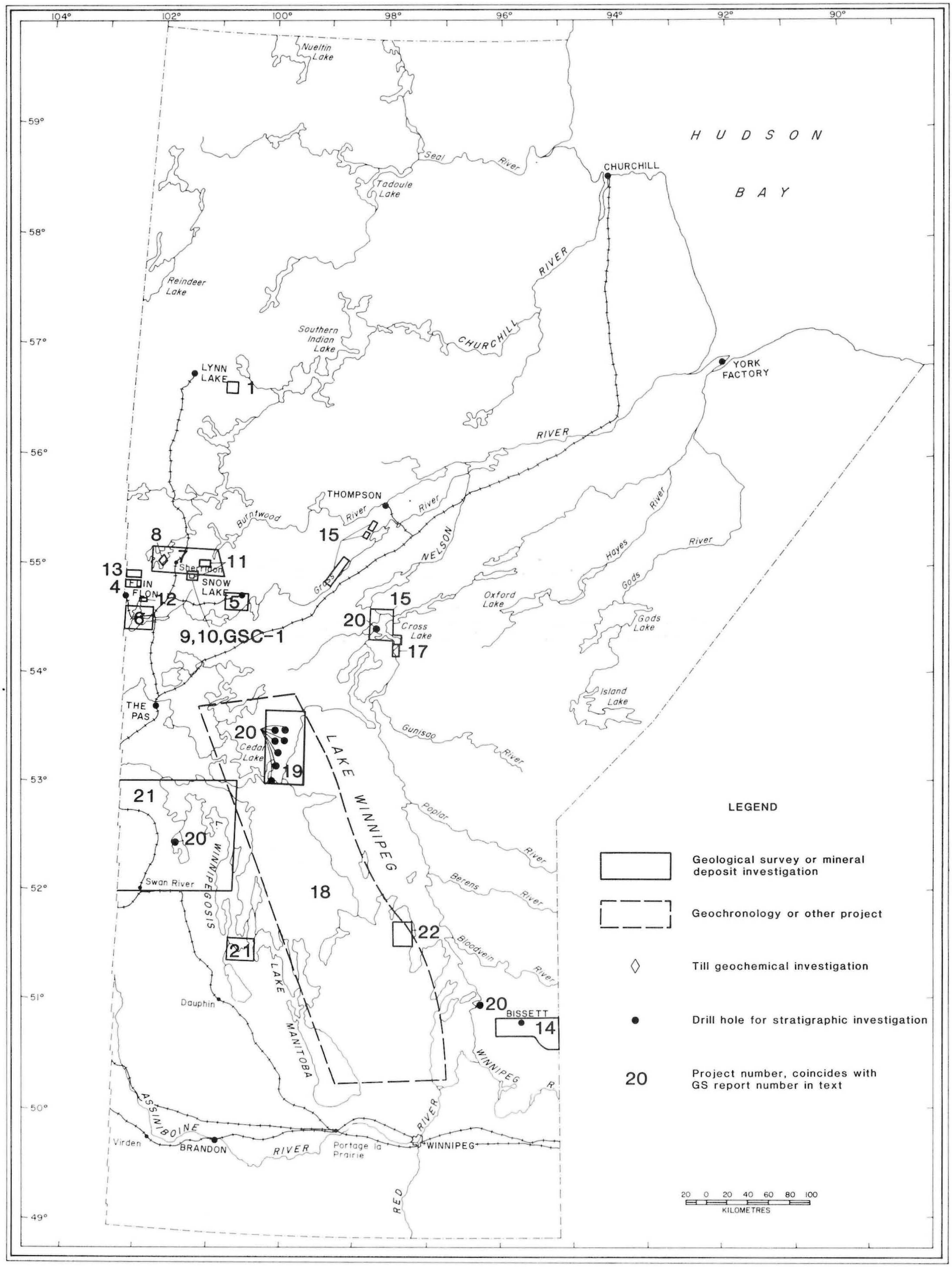

Figure GS-1: *Location of field projects 1989.*

INTRODUCTORY REVIEW

by W.D. McRitchie

McRitchie, W.D. 1989: Introductory review; in Manitoba Energy and Mines, Mineral Resources, Report of Field Activities, 1989.

During 1989 the operations of the provincial Geological Services Branch (GSB) were primarily geared to report and map production stemming from the previous five years of field surveys mounted under the Canada-Manitoba Mineral Development Agreement(MDA). Numerous publications were issued throughout the year including several new additions to the Mineral Deposit series of reports. A full listing of Provincial outputs generated under the MDA during the 5 year term (1984- 1989) is provided at the end of this publication.

The MDA process of developing an annual Workplan covering survey activities for the upcoming year, was repeated in the spring of 1989, along with distribution of this workplan to members of the Mineral Exploration Liaison Committee for critical review. Briefing sessions were again held in Winnipeg and northern centres to give explorationists in the regions an outline of the federal and provincial programs intended for the summer. An annual Progress Report for Sector "A" Geoscientific Activities conducted during 1988/1989 was released in June 1989.

The Provincial GSB mounted 22 MDA projects, 11 of which entailed field components of generally limited duration(Fig.GS-1). Fourteen new projects were also initiated as follow-up to the ongoing survey program in the province, and 10 of these involved an active field commitment. Student hiring was restricted to 17, and many of these were constrained to Winnipeg in support of data organization and processing.

Provincial operational budgets were set at $377.7K (MDA), and $379.4K (A-base).

Federal contributions (MDA and A-base), were limited to 5 field projects with an overall MDA budgetary allocation of approximately $163K. Most of the GSC personnel engaged in MDA projects during the 1984-1989 period were also committed to report and map production stemming from the earlier field projects.

A radiometric survey of the Ruttan-Eden lakes area, originally proposed for July, was postponed due to forest fires and rescheduled to May 1990.

The Radarsat office of the Canadian Centre for Remote Sensing undertook a Synthetic Aperture Radar survey of the Grand Rapids Uplands as part of a joint federal/provincial evaluation of this technology.

DISTRICT SUMMARIES

Lynn Lake-Leaf Rapids

A ground scintillometer reconnaissance of the Eden Lake monzonite confirmed the unique chemistry of the intrusion as well as the existence of elevated levels of REE and uranium in discrete but narrow zones.

A section of the Main Zone of the MacLellan Au-Ag deposit was mapped in detail and correlated with diamond drill hole and surface observations. The study resulted in the recognition of four main vein sets each with a unique associated alteration assemblage. Gold occurs within quartz-arsenopyrite veins formed towards the end stages of the latest ductile deformation, with minor remobilization associated with subsequent faulting.

An examination of the Johnson Shear Zone, the second metallotect in the region, concentrated on the Finlay McKinlay, and Prospector veins. A structural analysis of the veins concluded that the gold precipitation was a late event, occurring after the early ductile deformation and before brittle deformation associated with uplift.

Flin Flon-Snow Lake

Detailed mapping in the Tartan Lake-Embury Lake region completed coverage to the Saskatchewan border. At least three phases of faulting are recognized, the major block-bounding faults possibly being relatively early high-level faults with later reactivation. The recognition of extensive cross-faulting, especially in the Manistikwan Block, may have played a significant role in developing structures and favorable environments for ore deposition.

Detailed mapping in the Chisel Lake area is attempting to clarify the relationships between the base metal deposits in this region and their associated stratigraphic footwall alteration zones. The recent work has demonstrated that, although base metal deposits in the Snow Lake area share several attributes in common with those at Flin Flon(association with volcanics characterized by an island- arc chemistry, spatial association with fractionated volcanic rocks, and same stratigraphic position as major rhyolite complexes), the Chisel, Lost and Ghost deposits also have an association with synvolcanic plutons, large semiconformable footwall alteration zones, and volumetrically significant synvolcanic dyke complexes.

A two week program of confirmational and infill mapping, and sampling for whole-rock geochemistry and U/Pb geochronology, was conducted in the Athapapuskow Lake area as the final phase of a multiyear detailed mapping program in this region.

No new field work was conducted in the Kississing Lake area, efforts being directed toward completion of reports and maps stemming from the last five years detailed mapping and investigations.

Regional overburden sampling in the Kississing Lake area provided additional information on geochemical anomalies in the area, as well as local and regional background values for till geochemistry in the Kisseynew domain.

Documentation of mineralization and associated alteration zones in the Snow Lake area, and around the Pulver and Herblet Lake gneiss domes, has continued since 1984. Several new exploration targets are proposed as a result of the more recent work, which highlights the significance of garnetiferous alteration zones, as a potential host to base metal mineralization.

A geochemical study of the alteration zone associated with the North Cook Lake massive sulphide deposit demonstrated the presence of major and trace element, and mineralogical anomalies centred on the deposit including, Cu and Au haloes for about 85 m on either side of the mineralization. More restricted Sb and Pb anomalies are associated with the occurrence of near-solid and solid sulphides, and the deposit appears to coincide with a trough in the Mn content.

Twenty-six mineral occurrences in the Batty, Limestone Point, and Moody Lake areas were examined and described as part of the ongoing program of deposit documentation in the Churchill Province. Three weeks were also spent in investigating the structure and geology of the workings in the Puffy Lake gold mine.

As a follow-up to detailed geological mapping of the Baker-Patton felsic complex, drill core from the Cabin zone was sampled and logged. Previous interpretations regarding displacement of the ore-zone by faulting appear to be valid, and identification of a tuffaceous marker unit should help future exploration efforts in the area.

An important contribution was made in the Kisseynew Lake region by a mapping program that bridged the provincial border with Saskatchewan, providing correlation of units throughout this structurally complex zone. Lithologies representing high grade Amisk were identified well to the north of previously recognized occurrences supporting the contention that the Amisk volcanics were caught up in the tectonic events that affected the main Kisseynew gneissic belt. A more contentious recommendation arising from this study proposes extension of the term Amisk wackes to all greywacke-derived paragneisses in the Kississing Lake region.

Southeast-Manitoba

The inventory of mineral occurrences in the Bissett region is now complete, and the report in an advanced stage of production.

Thompson-Cross Lake

Detailed documentation of key sections in the Pipe II Open Pit Mine is helping to redefine, and give diagnostic lithological, geochemical, magnetic and petrographic signatures to supracrustal units in the Ospwagan Group. This comprehensive definition of stratigraphic sequences in the Thompson region will play an important role in supporting future exploration for stratabound mineralization.

In the Cross Lake region, fieldwork was related to checking conflicts of interpretation stemming from geochronological studies by D.Davis of the Royal Ontario Museum, and a thesis study by M. Breedveld of the Free University of Amsterdam on the thermo-tectonic evolution of the supracrustal belt.

The shoreline of the east channel of the Nelson River between High Hill Falls and Sugar Falls was mapped in order to complete regional coverage for this NTS map sheet and to set a regional environment for the detailed investigations of the Cross Lake Belt to the north. South of the Pipestone Lake anorthositic complex numerous granitoid lithologies are intensely sheared in a 1.5 km wide belt along the northern margin of the Molson Lake Domain.

Manitoba

In the past, numerous different approaches have been used to evaluate the potential for MVT lead and zinc deposits in the province's Paleozoic formations. This year attention switched to the northern Interlake region where abundant exposures of Silurian and Ordovician dolomites provide an ideal target for karst investigations, as well as geochemical investigations of groundwaters. Sampling programs focussed on creek waters and sediments along the northwest shore of Lake Winnipeg, as well as waters and sediments from the springs emerging from the base of the Silurian escarpment.

The appraisal of karst features in Manitoba's Interlake continued in cooperation with contributions from the University of Winnipeg and the Speleological Society of Manitoba. The total number of caves now reported exceeds 100 and a significant number have been mapped providing valuable information on the factors controlling the movement and behaviour of ancient and modern groundwaters in this region. Of particular significance was the discovery of numerous caves and a unique "Cockpit Karst" topography in parts of the Gypsumville region.

An extensive drilling program was conducted in various sectors of the province to provide key information on various aspects of Manitoba's industrial minerals as well as stratigraphic data to correlate Silurian and Ordovician sequences between the northern and southern Interlake. Drill core from five holes north of Grand Rapids will also be analysed for base metals as part of the MVT appraisal.

Other holes were drilled to evaluate high-silica sands at Manigotagan, Devonian reef structures at Swan Lake, building stone at Cross Lake, and chromite in an ultramafic body on Pipestone Lake.

Industrial mineral investigations focussed on the Swan River-Mafeking area, and on upgrading the maps of high-calcium limestone in the Dawson Bay, Point Wilkins region.

In southern Manitoba a six-week field program was conducted in the" St. Lakes" area to evaluate sphagnum peat bogs identified from previous remote sensing investigations. Of the twenty-five bogs sampled, eight appear to have high development potential, six have medium potential, and the remainder low potential.

During 1989 several improvements were made to drill core facilities in Winnipeg with additional core added to The Pas(3928m), Lynn Lake(1617m), Thompson(286m), and Winnipeg(335m). Work continued on the preparation of an Open File Report listing all holdings currently in the provincial system.

The Exploration Services Section continued to be active in a number of different fields, and generated several publications and brochures including the "Bibliography of Manitoba Geology 1795-1988". Early in 1989 the bibliographic database was transferred from an IBM mainframe to the section's PC, greatly improving the ease of retrievals and searches. An Open File report on Platinum Group metals was also generated, and updates made to the mineral inventory cards. Assessment data were used to develop an update of the 1978 publication on geophysical work in the Flin Flon region, and supplements to the Index to Non-confidential Assessment reports produced in May and November.

GEOLOGICAL SURVEY of CANADA

The broad range of projects conducted by the Geological Survey of Canada in the Province are reported in a separate publication to be issued as a GSC Open File at the province's Annual Open House in Winnipeg, November 1989. This publication contains reviews of all projects conducted during the five year period of the MDA as well as details of activities pursued during 1989. Three of the federally funded projects that involved substantial contributions by personnel from Manitoba are included within the provincial REPORT OF FIELD ACTIVITIES and these are summarized as follows.

A study was conducted to examine the metamorphic mineral assemblages in the North Cook Lake alteration zone, and to investigate the trace element variation in the host rocks to the occurrence.

1:1000 scale mapping of the Chisel Lake deposit was undertaken as a joint project to take advantage of the excellent exposures created during the development of the open pit mine. The results of this study will be integrated with the results of the 1:5000 scale mapping reported earlier in this volume. The studies are likely to make a significant contribution to exploration strategies in the Chisel Lake Basin especially in light of the important new discoveries being made by HBMS in this region.

A pilot study was conducted by research scientists at the University of Manitoba to investigate the possibility of geochemical haloes around the Bernic Lake rare-element-enriched pegmatite. Samples from drill core were analysed for a broad range of elements and initial results indicating wide zones of elevated lithium and rubidium about the ore body, may prove of use as an exploration tool in future searches for this kind of pegmatite.

GENERAL

Throughout the summer months GSB staff led, and partook in, numerous field demonstrations of the Flin-Flon/Snow Lake, Thompson and Lynn Lake areas for the benefit of industry and overseas geologists. GSB delegates took an active role in reporting on provincial programming at the September 11-13 Cluster meeting of the USGS and State Surveys in Bismark, North Dakota. Valuable new insights on Mississippi-Valley-Type lead-zinc deposits were also gained through attendance at the Mid-Continent Cluster meeting at St. Louis, Missouri.

Ancillary projects included examination of new exposures at the Conawapa site on the Nelson River, backhoeing of sinkholes at Gypsumville for dating and paleontological studies, in cooperation with personnel from the Museum of Man and Nature, and ongoing involvement with the exploratory activities of the Speleological Society of Manitoba.

The Branch's new Stratigrapher, Ruth Bezys, took over the responsibility of compiling the provincial contribution to the new Geological Atlas of the Western Canadian Sedimentary Basin, coordinated by the Canadian Society of Petroleum Geologists.

In addition to numerous other publications issued throughout the year, the Branch also supported the development of the province's first Geological Map Catalogue which will act as a guide to the geoscientific map resources available for Manitoba.

As in previous years Branch staff also provided ongoing assistance to other components of the Minerals Division, in giving commodity reviews and mineral resource assessments for various sectors of the province.

Several meetings were held with members of the federally commissioned MDA evaluation team from Goss, Gilroy and Associates. This five-province evaluation program will assess the relative merits of MDA programming over the last five years, including extensive interviews and questionnaires with industry and other clientele to determine the effectiveness of the activities in the context of regional economic development.

On September 5th the Department of Energy and Mines opened a new regional office at Flin Flon, staffed by a Mines Branch recording clerk, and a District Geologist who reports to the Geological Services Branch. This extension of year-round services reflects the Department's ongoing policy of supporting mineral-based communities and exploration endeavours in the most effective way possible.

Five year Workplans,(1989-1994), encompassing contributions from the federal and provincial Geological Surveys are well advanced and incorporate numerous suggestions and recommendations from industry

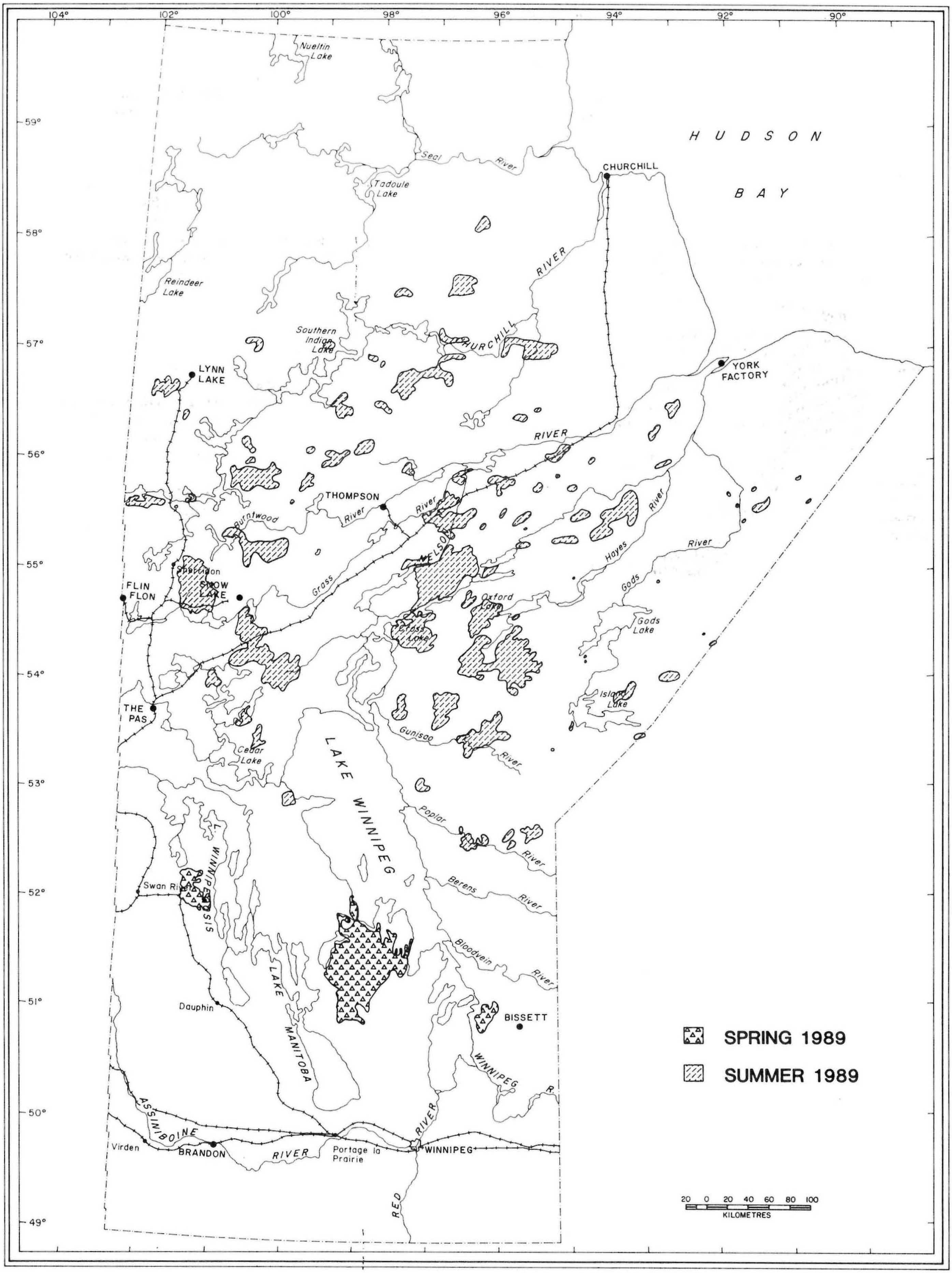

Figure GS-2: *Location of forest fires, spring and summer, 1989* exploration personnel. Negotiations between the Provinces and the Federal Government regarding renewal of the MDA's continued throughout the year. In August, at the Mines Minister's Conference in Sudbury, Ontario, the Federal Minister for EMR announced the decision to proceed with new MDA's in the Maritime Provinces. However in western Canada progress was limited to the setting of priorities for regional economic development through the Western Diversification Office.

In the absence of federal approvals for a new MDA the GSC has embarked on its EXTECH program which will focus "A-Base" resources into multidisciplinary studies of the Snow Lake and Ruttan region over the next 2-3 years.

The provincial GSB will coordinate its capabilities in support of EXTECH as well as developing other initiatives supporting future mineral developments and environmental concerns.

Program planning for a Lithoprobe transect of the Trans-Hudson Orogen is in the final stages. Should funding be approved in the spring of 1990, a multidisciplinary geophysical and geological program will be undertaken, mainly by the staff of the Department of Geological Sciences, University of Manitoba, and the GSC. The purpose will be to study the Precambrian crust from the northern Superior Province, across the Thompson belt, and the Proterozoic magmatic arcs and intra-arc basins of the Churchill Province in Manitoba and Saskatchewan. With the inclusion of high resolution seismic reflection surveys in selected areas this program will provide new data of importance to the exploration industry. The GSB will contribute high quality mapping in areas where such information is required. Reports dealing with the Branch's past work in the Trans Hudson Orogen are soon to be published in a special GAC symposium volume, along with the work of other agencies in Manitoba and neighbouring provinces.

Three new Precambrian bedrock geology compilation maps were issued during the last year. Additional maps in progress include sheets covering various sectors of the Province underlain by Paleozoic rocks.

During the spring and summer of 1989 the Province experienced one of the most widespread and extensive outbreaks of forest fires in recent history (Fig.GS-2). Although considerable damage was sustained to timber resources, the fire also opened up large areas of new bedrock exposure with an attendant short term opportunity for accelerated resource documentation. A comprehensive plan is currently under development that would take advantage of this "window of opportunity" for new mapping programs, especially in established mining districts with a proven potential for discovering new reserves. Fly-overs of burned areas were undertaken in October and an operational plan will be tabled for consideration as part of the 1990/1991 estimates process.

Computer usage in Energy and Mines has grown substantially over the last year. Extensive changes have been made involving automated drafting and report production using AutoCad and desktop publishing systems. Major systems developments include: continuing enhancement of the Paleozoic Stratigraphic Corehole system and its integration with Petroleum Branch files; development of outcrop-level Precambrian geology bases; and ongoing evaluation of new Geographic Information Systems and spatial analysis software.

Finally acknowledgements are made to Barry Bannatyne, Hugh McCabe, and Joe Athayde, all of whom retired this year after many years service with the Department. The contributions made by these individuals over the years will be remembered with sincere gratitude, and their integrity and industry will serve as a profound example for their successors to follow. In this context, and on behalf of the Branch, we welcome to their new positions Ruth Bezys (Stratigrapher), Dave Baldwin (Editor), Shirley Weselak(WP Operator) and Diana Kircz (Operations Coordinator).

W.D.McRitchie
October 1989

GS-1 GROUND SCINTILLOMETER RECONNAISSANCE OF THE EDEN LAKE AEGIRINE-AUGITE MONZONITE

by W. D. McRitchie

McRitchie, W.D. 1989: Ground scintillometer reconnaissance of the Eden Lake aegirine-augite monzonite; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

BACKGROUND

Routine geological mapping in 1978 and 1979 of the Lynn Lake region identified a 15 km^2 body of aegirine-augite-bearing monzonite and quartz monzonite between Eden and Kwaskwaypichikun lakes (Cameron, 1988) Coincident high levels of potassium, equivalent uranium and equivalent thorium are evident in airborne gamma ray spectrometer surveys of the region (Geological Survey of Canada 1977) and anomalously high uranium and fluoride in lake waters, and uranium in lake sediments were detected in the 1988 MDA geochemical sampling program by the Geological Survey of Canada (Schmitt *et al.,* 1989). The geochemical anomalies encompass a 40 km east-west and 20 km north-south area between Eden Lake and the Churchill River with a smaller tin anomaly (in lake sediment) over the Kwaskwaypichikun Bay region in the west.

Detailed sampling by McRitchie in 1988 confirmed the alkaline miaskitic chemical and mineralogical character of the intrusion and encountered elevated light rare earth elements (Table GS-1-1) in an allanite-bearing cognate zone of pyroxene enrichment on the eastern shoulder of the main ridges south of Kwaskwaypichikun Bay. Follow-up laboratory tests demonstrated elevated levels of radioactivity in the REE-enriched samples (1400 cps) and accordingly it was decided to mount a ground scintillometer reconnaissance over the region in an attempt to locate extensions to the zone discovered in 1988, as well as other possible occurrences.

Additional objectives were to provide a ground-based radiometric signature for the intrusion and to delineate the occurrence and nature of anomalously high radioactive zones that could be correlated with the concurrent airborne gamma ray survey of the intrusion being conducted by the GSC as part of its new EXTECH program. The results of this survey (flown at an altitude of 350 m on 1000 m line spacings) are likely to identify other anomalously high areas that will be targeted for ground spectrometer and scintillometer studies in 1990.

CURRENT WORK

The principal objectives set for 1989 were:

1. To search for extensions to the REE-enriched zone encountered in 1988; and
2. To obtain representative radioactive measurements for the Eden Lake monzonite that could be correlated with the subsequent airborne survey.

The initial plan was to obtain scintillometer readings on a 200 m grid encompassing the eastern ridge of the main Eden Lake outcrop belt and the intervening ill-exposed ground east to Kwaskwaypichikun Lake (Fig. GS-1-1). This approach was soon abandoned once it was found that most anomalies on the ridge were associated with point-sources or narrow zones, and that thick drift cover east of the ridge muted most of the scintillometer responses from this region. Accordingly, efforts were concentrated over the well exposed high ground, and a skeletal network of traverses was conducted with emphasis given to (east-west) profiles that would maximize the likelihood of intersecting the 024° trending REE and "uranium" enriched zones. Additional measurements were also taken over possible extensions to the monzonite east of Kwaskwaypichikun Bay (Fig. GS-1-1).

A Scintrex Broadband gamma-ray scintillometer model BGS-1SL (with a 1.5" x 1.5" thallium activated sodium iodide crystal) was used in conducting the survey. Background readings were taken each day from a boat over water depths exceeding 1 m. Spot measurements were taken on 78 stations in the 20 000 m traverse network both at waist level and on the ground. In most instances these were complemented by sweeps over open outcrop in the immediate vicinity of each station (Fig. GS-1-1) along with notation of spot highs between traverse stations. Sixteen measurements were also taken on shoreline outcrops of neighbouring granitic units for regional comparison.

RESULTS

Scintillometer readings from the alkaline intrusion are organized into four subareas corresponding to the west, central and east ridges of the main outcrop belt south of Kwaskwaypichikun Bay, and the region north of Kwaskwaypichikun Lake. Measurements taken on shoreline outcrops of the outlying granitic rocks are listed separately (Table GS-1-2). Data presented in Tables GS-1-1, and GS-1-2 are to read in conjunction with Figure GS-1-1.

Daily background readings ranged from 25-30 cps. Noticeable drop-off in counts per second were noted over all overburden areas, especially in wet open swamps where source rocks are presumably covered by thick overburden.

Waist-level and on-the-ground measurements differ markedly over hot-spots and along zones of strong radioactivity however little or no contrast was noted for background readings taken in areas of open outcrop. A thin veneer of soil or clay (10-20 cm) was found to cause a moderate fall-off in readings taken at waist level.

Monzonite outcrops in all three ridges consistently give readings of 150-300 cps with the greater proportion being near the upper level of this range. This is consistently higher than readings obtained from the outlying granitic phases which range from 100-150 cps.

No systematic regional differences between one ridge and another were noted in the course of the present skeletal coverage, hot-spots tending to be clustered locally in all three outcrop areas. The northern end of the western ridge gives slightly lower readings (150-250 cps).

Anomalously high responses were obtained in association with the following features:

1. Extremely localized (1200-6000 cps) hot-spots (10-20 cm) corresponding to individual or clustered radioactive minerals.
2. Local hot-spots (1000-4000 cps) corresponding with (30 cm- 1.5 m) fractures exhibiting splayed terminations.

TABLE GS-1-1 EDEN LAKE MONZONITE
(Zones of elevated REE from region between Eden and Kwaskwaypichikun lakes)

Sample description	SC PPM	TH PPM	U PPM	LA PPM	CE PPM	ND PPM	SM PPM	EU PPM	TB PPM	YB PPM	LU PPM
04-89-31-1	2.9	3500	1180	13700	36500	20700	3060	600	180	54	21
04-89-08-1	2.9	1800	880	17700	45900	22900	3300	680	180	68	16
04-89-084C	1.9	2100	1400	13800	39600	24300	3150	670	180	27	14
04-88-06-5	2.47	775	690	12100	15000	6140	1840	247	65.9	55.5	5.13
04-88-00-5(2)*	-	-	369	7180	12700	5530	1070	161	97.8	40.0	4.77

*Check analysis

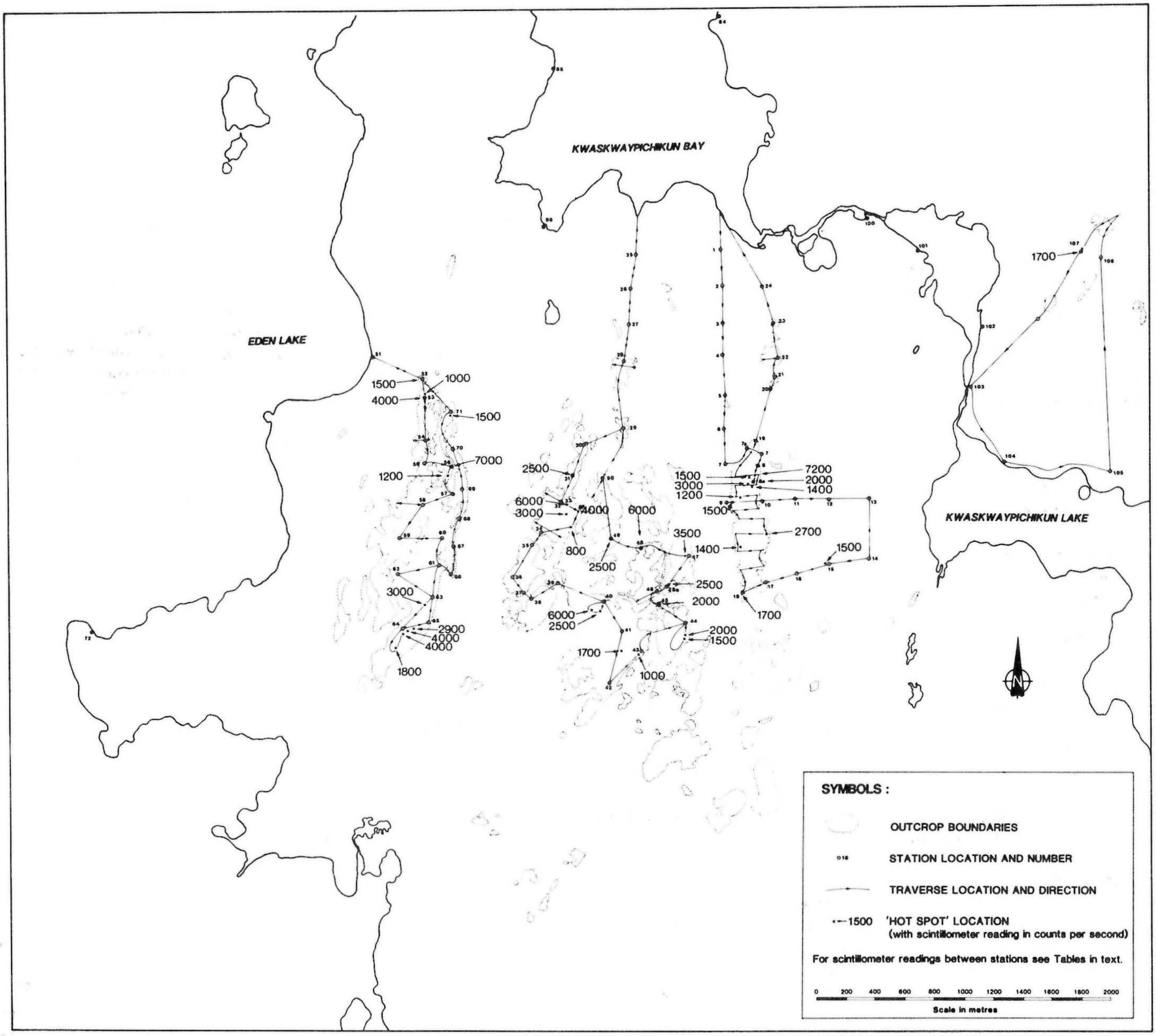

Figure GS-1-1: Ground scintillometer reconnaissance of Eden Lake monzonite

3. 300-024° azimuth zones, (1200-7000 cps varying along strike but consistently high) 6-40 m long and 5-20 cm thick containing elevated levels of brown, glassy allanite and possible uranophane, as well as prominent concentrations of coarse grained (up to 1.5 cm) pyroxene segregations in layers and lenses - these may also have an associated overprinting foliation.
4. Discordant fine grained, buff coloured layers (2-6 cm thick, and up to 5 m long); no observed offset in associated host phases.
5. 11-20 m zone of elevated readings (400-1500 cps) in association with shallow dipping complex of aplite, pegmatite, syenite.
6. 024° azimuth, 5 m wide, 150 m + long zone of finer grained syenite with prominent rusty weathering (readings from 400- 1600 cps).

Most occurrences with elevated readings exhibit a prominent rusty weathering, that is associated with oxidized pyrite mineralization. Forty of the features were "hot spots" of limited lateral extent, four constituted pyroxene and allanite-enriched zones ranging in length from 1.5 to 40 m with cps 2500-7000, and three were 3 m, 5 x 150 m and 11 x 25 m zones of moderately elevated readings ranging from 400-500, 400-800, and 400-1500 cps, respectively.

Analytical and microscope studies are currently in progress to determine the mineralogy and chemistry of the anomalous zones.

Although the current work has confirmed the unique chemistry and mineralogy of the Eden Lake intrusion (Fig. GS-1-2) as well as the existence of elevated levels of high REE (Table GS-1-1) and uranium, none of the observed anomalies appear of economic significance. Subsequent follow-up work will be limited to an evaluation of new targets resulting from the more regional airborne gamma ray surveys conducted by the GSC.

TABLE GS-1-2
MONZONITE - EAST RIDGE

STATION #	OUTCROP/NON-OUTCROP/ BOULDERS	WAIST	GROUND	SCINTILLOMETER READINGS cps RANGE	SPOT HIGH(S)	ZONES L/READING
1	N	75	90	-	-	-
1-2	N	-	-	90	-	-
2	B	80	90	-	-	-
2-4	N	-	-	80	-	-
	B	100	110	-	-	-
3-4	N	-	-	90	-	-
4	B	120	120	-	-	-
4-5	N	-	-	-	-	-
5	B	100	120	-	-	-
5-6	N			-	-	-
6	B	110	120	-	-	-
6-7	N	-	-	-	-	-
7	B	120	120	-	-	-
7-8	O	-	-	200-220	-	-
8	O	180	220	200-260	-	40 m/7000
8-9	O	-	-	200-400	1400	30 m/3000
9	B	150	150	-	1500	-
9-10	O	-	-	230-250	1200	-
10	N	160	160	-	-	-
10-11	N	-	-	120-130	-	-
11	O	150	200	-	-	-
11-12	N	-	-	70-100	-	-
12	O	250	250	-	-	-
12-13	N	-	-	80	-	-
13	N	50	50	-	-	-
13-14	N	-	-	70	-	-
14	N	80	80	-	-	-
14-15	N	-	-	-	-	-
15	O	250	400	-	800-1500	-
15-16	N	-	-	-	-	-
16	N	60	60	-	-	-
16-17	N	-	-	-	-	-
17	O	170	250	-	-	-
17-18	O	-	-	150-220	-	-
18	O	220	220	-	1400-1700	-
18-19	O	-	-	200-250	-	-
19	O	250	280	-	-	-
19-20	N	-	-	-	-	-
20	O	200	220	-	-	-
20-21	O	-	-	-	-	-
21	O	200	220	-	-	-
21-22	O/N	-	-	-	-	-
22	O	160	220	-	-	-
22-23	O	-	-	-	-	-
23	O	150	150	-	-	-
23-24	N/B	-	-	-	-	-
24	N	100	100	-	-	-

*Background 25 cps

MONZONITE - CENTRAL RIDGE

STATION #	OUTCROP/NON-OUTCROP/ BOULDERS	SCINTILLOMETER READINGS cps WAIST	GROUND	RANGE	SPOT HIGH(S)	ZONES L/READING
Shore	N	70	-	-	-	-
25	N	100	-	-	-	-
25-26	N	-	-	-	-	-
26	B	140	140	-	-	-
26-27	B	-	-	-	-	-
27	B	120	120	-	-	-
27-28		-	-	-	-	-
28	O	150	150	-	-	-
28-29	O	-	-	150-170	-	-
30	O	150	150	-	250	-
30-31	N	-	-	-	-	-
31	O	150	150	-	2500	1.5 m/2500
31-32	O	-	-	200-220	-	-
32	O	250	400	-	-	-
32-33	O	-	-	200-300	-	-
33	O	250	280	-	6000/3000/4000	150 m/400-800
33-34	O	-	-	170-250	1000/1000/3000	-
34	O	160	220	-	-	-
34-35	N	-	-	-	-	-
35	O	150	250	-	-	-
35-36	O	-	-	150-200	-	-
36	O	150	200	-	-	-
36-37	O	-	-	150-200	-	-
37	O	200	200	-	-	-
37-38	N	-	-	-	-	-
38	O	170	170	-	-	-
38-39	O	-	-	150-200	-	-
39	O	200	200	-	-	-
39-40	O	-	-	150-200	6000/2500	-
40	O	200	230	-	-	-
40-41	O	-	-	170-220	-	-
41	O	190	220	-	-	-
41-42	O	-	-	-	1700	-
42	O	150	200	-	-	-
42-43	O	-	-	200-250	1000	-
43	O	250	250	-	-	-
43-44	O	-	-	200	-	-
44	O	280	310	200/-	1500	-
44-45	O	-	-	250-300	-	-
45	O	200	200	200-400	600/2000	-
45-46	O	-	-	-	-	-
46	O	230	230	200-300	-	-
46-47	O	-	-	250-300	2500	-
47	O	300	350	300-500	3500/2000	-
47-48	O	-	-	250-300	-	-
48	O	230	230	-	600/6000	-
48-49	O/N	-	-	350	-	-
9	O	400	400	400-600	2500	11x35m/400-1 500
49-50	O	-	-	250-300	-	-
50	O	250	270	400-500	-	-

MONZONITE - WEST RIDGE

STATION #	OUTCROP/NON-OUTCROP/ BOULDERS	SCINTILLOMETER READINGS cps WAIST	GROUND	RANGE	SPOT HIGH(S)	ZONES L/READING
51	N	120	120	-	-	-
51-52	N	120	-	-	-	-
52	O	150	150	-	1500	-
52-53	O	170	-	-	-	-
53	O	170	200	-	-	6 m/4000
53-54	O	-		150-200	-	-
54	O	150	180	-		3M/400-500
54-55	O	-	-	150-200	-	-
55	O	150	200	150-200	-	-
55-56	O	-	-	150-200	-	-
56	O	160	250	-	1600/7000	-
56-57	O	-	-	200-250	1200	-
57	O	200	250	400	-	-
57-58	O	-	-	150-200	-	-
58	O	150	200	250-300	1200	-
58-59	O	-	-	200-250	-	-
59	O	200	250	180-230	-	-
59-60	O	-	-	200-250	-	-
60	O	200	250-	-	-	-
60-61	O	-	-	200 +	-	-
61	O	200	200	180-250	-	-
61-62	O	-	-	170-250	-	-
62	O	200	200	200-250	-	-
62-63	O	-	-	-	-	-
3	O	200	200	200-250	-	-
63-64	O	240	240	240-250	3000	-
64	O	240	240	150-200	1800/4000/4000	-
64-65	O	-	-	200-250	2900	-
65	O	200	200	-	-	-
65-66	O	-	-	200-250	-	-
66	O	200	200	-	-	-
66-67	O	-	-	-	-	-
67	O	150	150	-	-	-
67-68	O	-	-	200	-	-
68	O	200	200	-	-	-
68-69	O	-	-	-	-	-
69	O	150	180	150-200	-	-
69-70	O	-	-	150-200	-	-
70	O	180	180	-	-	-
70-71	O	-	-	-	-	-
71	O	150	150	150-200	1400	-
71-52	O	-	-	100-150	-	-
72	O	-	160-200	-	-	-
86	O	-	140-200		-	-

OTHER GRANITIC ROCKS

STATION #	OUTCROP/NON-OUTCROP/ BOULDERS	SCINTILLOMETER READINGS cps WAIST	GROUND	RANGE	SPOT HIGH(S)	ZONES L/READING
73	O	-	100-200	-	-	-
74	O	-	100-150	-	-	-
75	O	-	100-140	-	-	-
76	O	-	140-160	-	-	-
77	O	-	120-140	-	-	-
78	O	-	100-120	-	-	-
79	O	-	90-110	-	-	-
80	O	-	120-160	200	-	-
81	O	-	100-130	160-170	-	-
82	O	-	110-140	170	-	-
83	O	-	80-110	150	-	-
84	O	-	120-140	-	-	-
85	O	-	120-160	200	-	

MONZONITE - KWASKWAYPICHIKUN-NORTH

100	O	100	170	-	-	-
101	O	150	250	250-300	-	-
102	O	100	200	300	-	-
103	O	100	150	-	-	-
103-104	N	-	-	110	-	-
104	N	90	90	-	-	-
104-105	N	-	-	90-120	-	-
105	N	80	80	-	-	-
105-106	N	-	-	120-180	-	-
106	N	-	-	-	-	-
106-107	N	-	-	170-190	-	-
107	O	150	150	150-250	1700	-
107-102	N	-	-	140-150	-	-

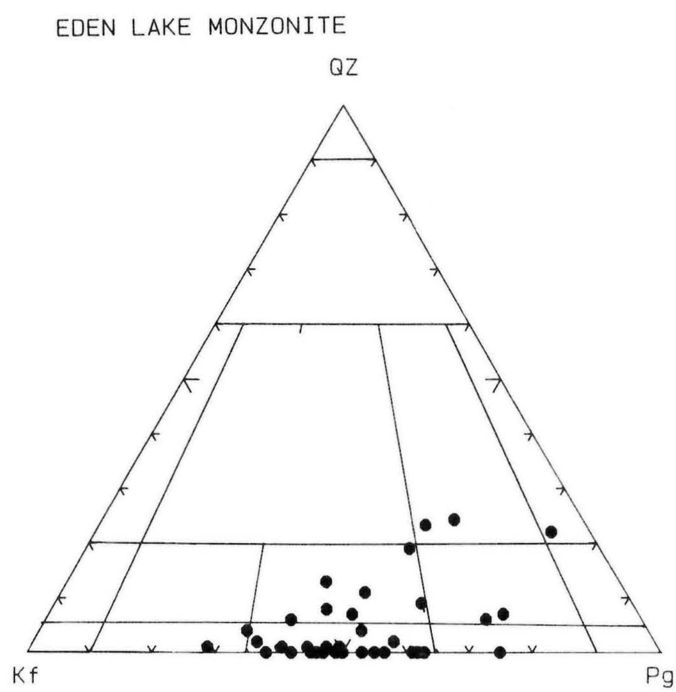

Figure GS-1-2: Modal analyses (plagioclase/quartz/potassium feldspar) from Eden Lake monzonite

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GS-2 GEOLOGY, MINERALIZATION AND ALTERATION IN THE MacLELLAN Au-Ag DEPOSIT, LYNN LAKE, MANITOBA

by J.E. Gagnon[1] and I.M. Samson[1]

Gagnon, J.E. and Samson, I.M. 1989: Geology, mineralization and alteration in the MacLellan Au-Ag deposit, Lynn Lake, Manitoba; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The MacLellan Au-Ag deposit occurs in a sequence of predominantly mafic metavolcanic rocks that belong to the Aphebian age Wasekwan Group within the Lynn Lake greenstone belt, northern Manitoba. A detailed study of the Main Zone orebody was initiated in 1987 in order to develop a better understanding of various aspects of the deposit's genesis, including the controls on ore deposition and the timing of gold emplacement with respect to deposition (syngenetic vs epigenetic), deformation, and metamorphism. This report summarizes the results of a detailed field, petrographic and mineralogical study of a cross section through the deposit, and the implications of the observations for the genesis of the mineralization. Mineralogy was determined by optical microscopy, x-ray diffraction, and electron microprobe analysis.

LOCAL GEOLOGY

A section of the Main Zone orebody was mapped at a scale of 1:100 and correlated with diamond drill hole and surface observations. The ore zones of the MacLellan deposit are hosted by an east trending, subvertical sequence of mineralogically and lithologically complex interlaminated chlorite-amphibole-plagioclase schists and quartz-biotite schists. These have been interpreted to be tholeiitic, picritic volcanic flows and fine-grained metasedimentary rocks (siltstones) respectively (Fox and Johnson, 1980; Fedikow, 1986). The main zone orebody is stratiform, but is sub-parallel to the host lithologies. The sequence has been complicated by the formation of several pre- and syn- deformation vein sets and their associated hydrothermal alteration zones and by a late faulting event.

ORIGINAL LITHOLOGIES

Three primary (pre-vein) metamorphic lithologies have been recognized. These are: amphibole-chlorite schist; quartz-biotite schist; and muscovite-plagioclase schist.

Amphibole-chlorite schist comprises ferroan clinochlore ± hornblende ± plagioclase ± magnetite ± ilmenite. Amphibole content varies considerably. This rock has been interpreted as a tholeiitic picrite on the basis of its major element chemistry (Fox and Johnson, 1980). The mineral assemblage is indicative of greenschist facies metamorphism.

Quartz-biotite schist comprises quartz + biotite ± chlorite ± staurolite ± garnet ± magnetite and has been interpreted as a metasiltstone (Fedikow, 1986).

Muscovite-plagioclase schist, which has not previously been identified, comprises muscovite + plagioclase + quartz. All of these lithologies have a well developed, steeply dipping continuous foliation and have a variably developed, gradational to disjunctive crenulation cleavage. The former indicates formation during or before a deformation event that preceded vein development and alteration. The crenulation may have been caused by the deformation event that affected some of the vein sets (see below).

VEINING AND ALTERATION

Four distinct vein sets have been identified within the main ore zone. Each set has a unique associated alteration assemblage with that varies with the composition of the host rock.

Vein Set 1

Vein set 1 comprises small, discontinuous, foliation-parallel, quartz-biotite-pyrite-pyrrhotite veinlets. These average less than 2 cm in width and are generally less than 0.5 cm.

Association with the emplacement of these veinlets, the chlorite-amphibole schist (picrite) has been pervasively replaced by zones of massive, coarse grained biotite + pyrrhotite ± pyrite ± tourmaline. The muscovite-plagioclase schist has been altered to an assemblage of plagioclase + K- feldspar + quartz + biotite + pyrrhotite ± pyrite ± tourmaline.

This set of veinlets is highly deformed and has the appearance of laminated quartz-biotite-iron sulphide or biotite-sulphide schists. The quartz laminations in such rocks are boudinaged, recrystallized (granulated) quartz veinlets. Deformation has also resulted in the formation of small shear zones within biotite-rich areas.

Vein Set 2

Vein set 2 consists of 10 to 25 cm wide, quartz-hornblende- carbonate ± pyrrhotite veins. These veins occur in all of the previously described lithologies. They cross-cut vein set 1, are subparallel to foliation and are boudinaged. The picrite, where penetrated by vein set 2, has been pervasively amphibolitized. This is characterized by the development of coarse, fan shaped tremolite that replaces hornblende. The quartz-biotite and muscovite-plagioclase schists also exhibit vein-related amphibolitization. The amphibole is non-foliated (granoblastic) and overprints all other minerals. In addition, sericite is present in a fine grained assemblage that is an alteration product of feldspar in the muscovite-plagioclase schist.

Vein Set 3

Vein set 3 comprises 0.5 to 30 cm wide quartz-arsenopyrite veins and replacement bodies. These occur in all lithologies, but are noticeably less abundant in the picrite. These veins are sub-parallel to foliation and only slightly boudinaged. Quartz-arsenopyrite veinlets, which extend into the immediate host rocks, exhibit ptygmatic folding. The wallrocks adjacent to these veins are silicified and show development of pale green, fibrous amphibole overgrowths in the picrite and granoblastic amphibolite. Where penetrated by vein set 3, the quartz-biotite-sulphide schists exhibit silicification, minor recrystallization of biotite, and formation of gahnite, tourmaline, and pale green fibrous amphibole. The muscovite-plagioclase schist has been silicified and recrystallized into an aluminous assemblage comprising andalusite-staurolite-sillimanite-biotite-arsenopyrite-quartz ± tourmaline, and fibrous amphibole.

Plots of gold-silver-arsenic assay values against simplified geology (Fig. GS-2-1) illustrates that significant gold- silver mineralization is spatially associated with this vein set.

Vein Set 4

Vein set 4 consists of planar, 5 to 30 cm wide quartz-galena-sphalerite-pyrite-arsenopyrite veins. These veins exhibit minor boudinage, but do not appear to have associated alteration. These veins cut the primary foliation and vein sets 1 to 3 at an angle of 40° to 60°, and developed contemporaneously with late faults.

MINERAL CHEMISTRY

Preliminary electron microprobe analyses of metamorphic, alteration, and vein amphiboles and biotites (Fig. GS-2-2). show that the chemistry of these minerals is quite variable and is controlled, at least in part, by the chemistry of the immediate host rock. Amphiboles from the picrite contain more Mg and Ca and less Fe and Al than those from the quartz-biotite schist. Similarly, biotites from the picrite have higher Mg/Fe ratios than those from the quartz-biotite schist. There is little information on how mineral chemistry varies with respect to the temporal development of the system. The only significant observation is that amphiboles associated with vein set 3 are more calcic and magnesian than earlier formed amphiboles.

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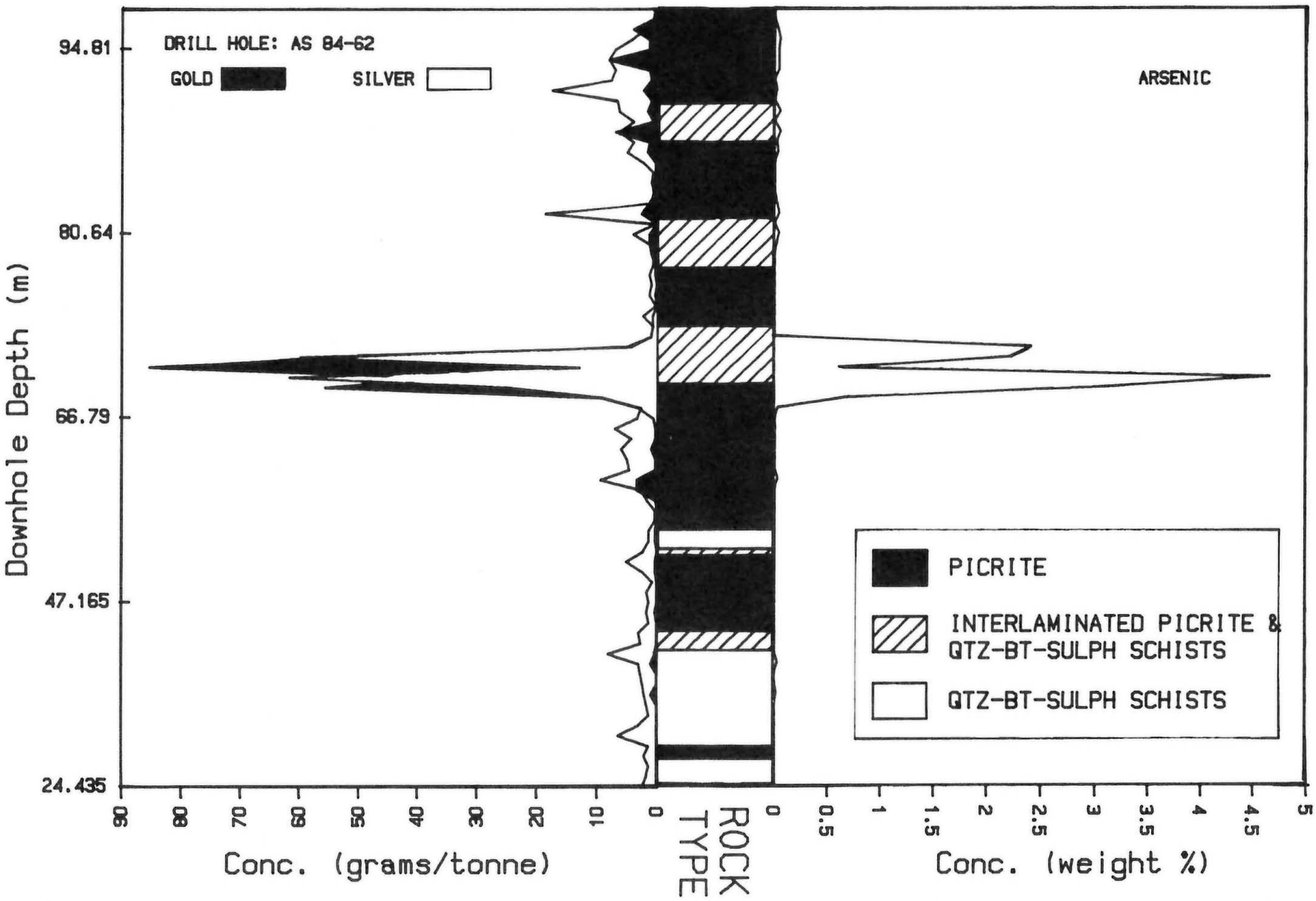

Figure GS-2-1: *Correlation of Au and Ag concentration with As concentration and lithology in diamond drill core AS 84-62. Note the correlation of high Au and Ag concentration with As.*

DISCUSSION

Fox and Johnson (1980) suggested that the granoblastic amphibolite is the least altered of the picritic rocks and that the chlorite schist is the most altered. Field and petrographic observations reported above show that the opposite is true, and that amphibole rich rocks can develop through the alteration of a variety of assemblages. The alteration assemblages represent 'higher grade' minerals than expected for the regional metamorphism. Thus our observations also disagree with the interpretation that greenschist facies assemblages in this part of the belt are retrograde (Gilbert *et al.*, 1980).

The quartz-biotite and biotite-iron sulphide schists have been interpreted as metasiltstones and associated iron formation (Fedikow, 1986). As a result of this interpretation, and the fact that vein set 3, which carries the gold, is principally hosted by these units, Fedikow (1986) proposed a syngenetic exhalative origin for the gold mineralization and subsequent concentration due to remobilization of gold into quartz veins. Although some quartz-biotite schists are probably sedimentary in origin, our interpretation of the biotite-iron sulphide schists as a deformed alteration assemblage, and the association of the gold with the quartz-arsenopyrite veins (Fig. GS-2-1), leads us to the conclusion that the mineralization is epigenetic. Fedikow (1986) noted the presence of arsenopyrite, but did not recognize its association with a distinct phase of veins. Minor concentrations of gold occur in vein set 4; it probably represents later remobilization. The development of the hydrothermal alteration assemblages probably did not involve Fe, Ca, Al, or Mg metasomatism. However, addition of K, S, and Si were required for potassic alteration and sulphidation of the picrite and for silicification associated with vein set 3.

CONCLUSIONS

1. Gold mineralization is principally associated with quartz-arsenopyrite veins. These veins formed toward the end stages of a late ductile deformation. Minor remobilization of gold occurred during later veining associated with faulting.
2. The Main Zone orebody is stratiform because vein development was controlled by a foliation that developed sub-parallel to the host strata and vein emplacement occurred preferentially in the more siliceous lithologies that are stratiform in nature.
3. Biotite-iron sulphide schist and granoblastic amphibolite, which had previously been interpreted as unaltered metasiltstone and metapicrite respectively, are hydrothermal alteration assemblages associated with two stages of quartz vein formation.

ACKNOWLEDGEMENTS

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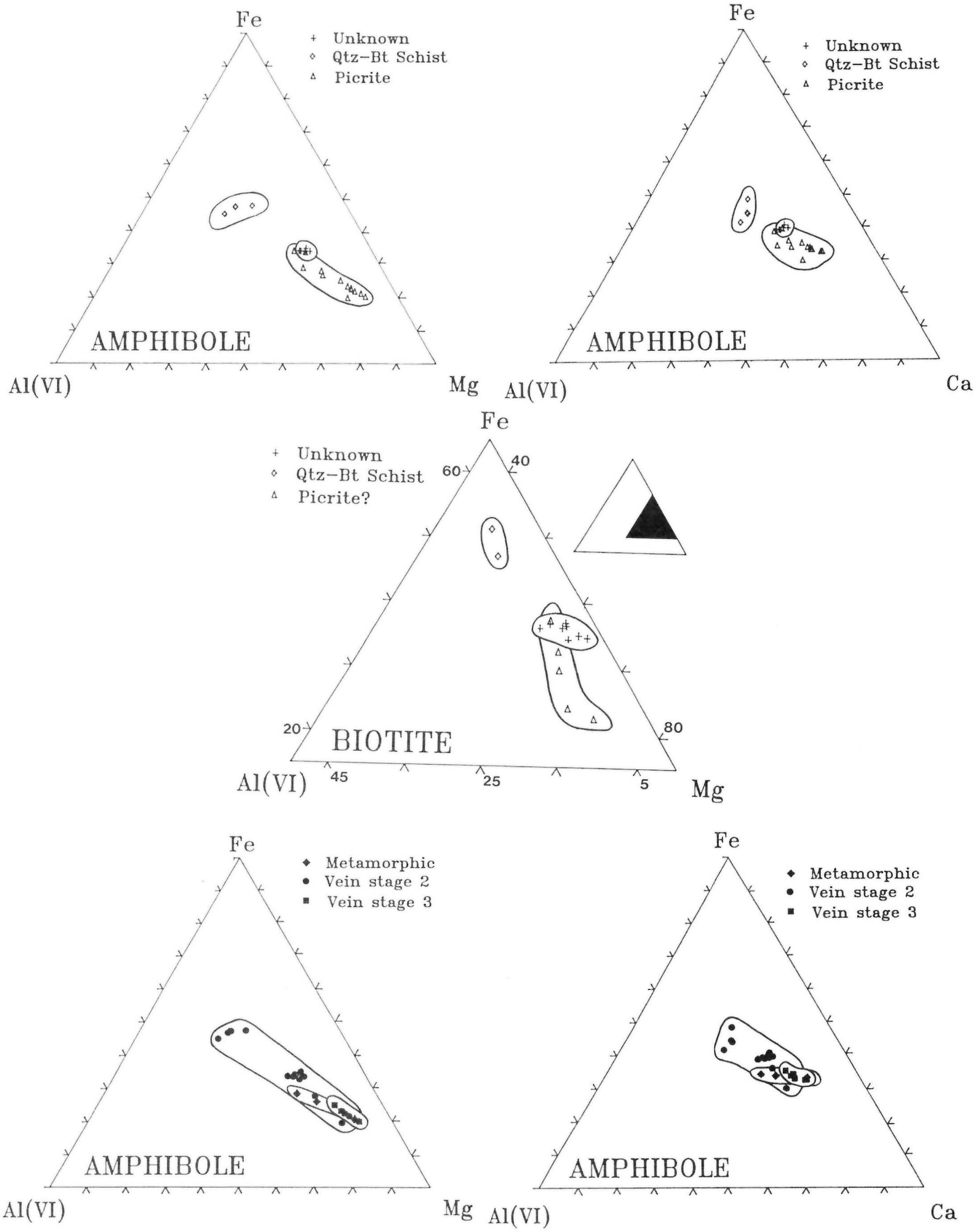

Figure GS-2-2: *Cation proportions in biotite and amphibole as a function of host lithology and time of formation. Calculated from electron microprobe data.*

GS-3 DEFORMATION, VEINING AND GOLD MINERALIZATION ALONG PART OF THE JOHNSON SHEAR ZONE, LYNN LAKE GREENSTONE BELT, MANITOBA

by G.R. Sherman[1], I.M. Samson[1] and P.E. Holm[1]

Sherman, G.R., Samson, I.M. and Holm, P.E. 1989: Deformation, veining and gold mineralization along part of the Johnson shear zone, Lynn Lake greenstone belt, Manitoba; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The southern belt of the Lynn Lake greenstone belt (Gilbert *et al.*, 1980) contains numerous quartz-vein type gold occurrences along a 35 km long regional lineament known as the "Johnson Shear Zone" (Bateman, 1945).

This study was initiated to investigate gold mineralization at the western extension of the Shear Zone, south of Gemmell Lake. The study has two main objectives:

1. to determine the timing of gold mineralization within the study area with respect to the geological and tectonic history of the Lynn Lake greenstone belt; and
2. to assess the possible precipitation mechanisms for gold based on hydrothermal mineral assemblages and fluid inclusion analysis.

During the summer of 1988, the Shoe Lace Claim Block 7811 was mapped at a scale of 1:2 400 and detailed mapping at scales of 1:300 and 1:30 was completed for the Prospector and Finlay McKinlay vein sets, respectively.

This report summarizes vein development and the relationship between geology of the study area in addition to some preliminary conclusions on timing of the gold mineralization.

GENERAL GEOLOGY

The study area is located south of Gemmell Lake in the southwestern portion of the Lynn Lake greenstone belt. The stratigraphic succession consists of Wasekwan Group felsic to mafic metavolcanic and metasedimentary rocks, pre-Sickle intrusive rocks and Sickle Group conglomerate. The geology of the Gemmell Lake area has been described by several authors including Gilbert *et al.* (1980), Baldwin (1987) and Sherman *et al.* (1988).

DEFORMATION

Four deformation events have affected the rocks within the study area. Three major structures that have been identified include an overturned anticline and two brittle- to ductile fault zones.

The first event (D_1) resulted in the development of a regional foliation (S_1) and lineation (F_1) in Wasekwan and Sickle group supracrustal rocks and pre-Sickle intrusive rocks.

Wasekwan and Sickle groups rock display a northeast trending penetrative foliation (S_1), which dips steeply to the northwest (Sherman *et al.*, 1988). Associated with the S_1 foliation is a north plunging lineament (L_1) that is defined by elongation of sedimentary clasts, aggregates or grains, and alignment of chlorite, biotite and sericite (Sherman *et al.*, 1988).

The Wasekwan Group comprises a conformable sequence of mafic to felsic metavolcanic and metasedimentary rocks that contain flow top breccia and pillowed mafic metavolcanic rocks which indicate the sequence youngs toward the north. The Sickle Group conglomerate is a poorly sorted, polymictic conglomerate that contains abundant clasts of adjacent Pre-Sickle intrusive rock (Sherman *et al.*, 1988). The unconformity at the base of the Sickle Group 255° and dips north at 74°. An overturned anticline (F_1) with its axial plane located within the Pre-Sickle intrusive rocks is inferred based on younging criteria and the relationship of the unconformity.

The second deformation event (D_2) entailed regional folding that is inferred from a non-penetrative crenulation cleavage (S_2) superimposed on S_1 foliation. These S_2 structures are generally weak, northeast trending biotitic crenulations, which are locally developed within felsic metavolcanic and metasedimentary rocks of the Wasekwan Group.

Minor asymmetric folds (F_2) are well developed in Wasekwan Group metasedimentary rocks. Axial surfaces strike northeast, and hinge lines trend 000° to 040° and plunge 50° to 90° north.

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A brittle-ductile shear zone has been identified on the Finlay McKinlay vein outcrop. It exhibits well developed mylonitic textures, a strong L-S fabric typical of ductile shear zones, small brittle faults, brecciation and pseudotachylite.

At this outcrop, diorite exhibits a complete gradation in the degree of deformation from undeformed quartz diorite to protomylonite, mylonite and ultramylonite (Sherman *et al.*, 1988).

Within the 30 to 40 m wide planar shear zone foliation (S_3) is oriented at 225° to 230° and steeply dips to the NE at 70° to 80° (Fig. GS-3-1a). Elongation of original quartz grains, alignment of biotite, chlorite and pyrite, and formation of quartz ribbons define a linear fabric (L_3). It is oriented to the north and plunges 50° to 80° (Fig. GS-3-1b). Preliminary observations of kinematic indicators suggest oblique, reverse displacement along the shear zones, which mylonite development could be related to D_2 or it could represent a separate ductile deformation event. However, because the mylonite is restricted to the diorite, which does not exhibit any penetration, regional foliation, its relationship to the D1 and D2 events is unclear.

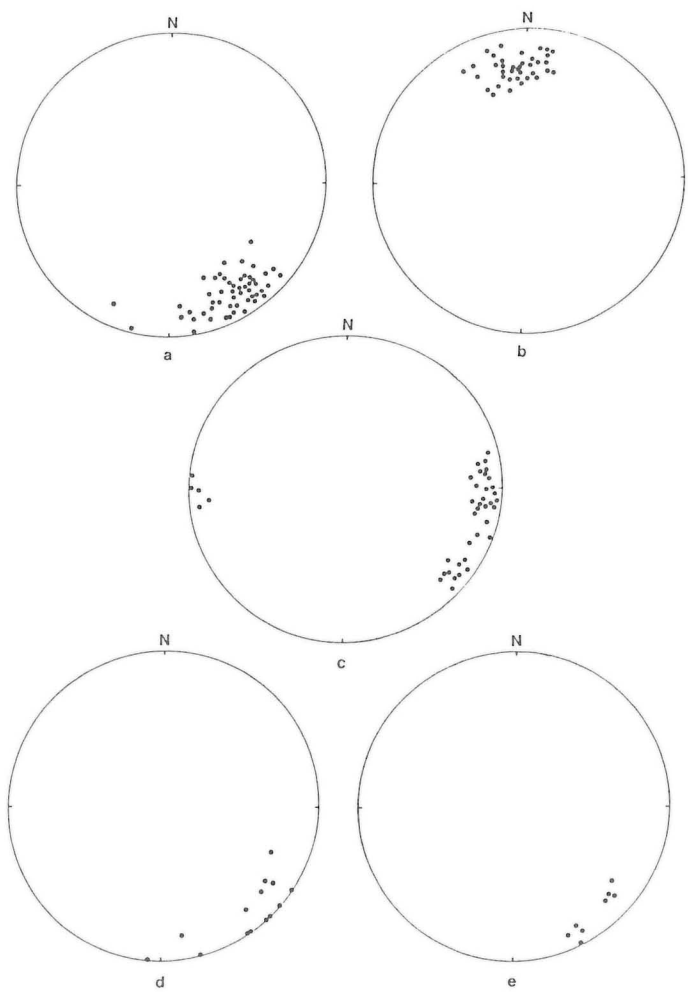

Figure GS-3-1. *Equal area stereonet projections of structural data from the Finlay McKinlay exposure: a. poles to the S_3 (mylonite) foliation; b. lineation within the mylonite (L_3); c. poles to veins; d. poles to brittle faults; e. poles to pseudotachylite fault veins.*

Within the shear zone, brittle deformation (D_3) disrupts the mylonitic textures and the L-S fabrics. Displacement on small sinistral faults is up to 0.5 m. The orientation of the faults varies from 200° to 255° with a steep northeast dip Fig. GS-3-1d) similar to the orientation of the shear zone (Fig. GS-3-1a).

A zone of brecciation and pseudotachylite development is localized at the contact of a large quartz-sulphide vein and diorite in the central portion of the shear zone. The width of this zone extends approximately 1 m north of the vein; it can be followed to the east limit of the outcrop. The zone cross-cuts and disrupts the mylonitic fabric. Pseudotachylite varies in colour from light gray to brown to black. It forms fault veins, injection veins and breccias (terminology after Gibson, 1975). Some pseudotachylite appears vesicular. Pseudotachylite fault veins attach a maximum thickness of 10 mm and vary in orientation between 218°/69° to 244°/90° (Fig. GS-3-1e). The injection vein have a maximum thickness of 18 mm and maximum length of 14 cm; in some cases the injection veins can be traced to a fault vein. The pseudotachylite breccia consists of wallrock fragments supported in a matrix of pseudotachylite. The largest breccia zone is directly adjacent to, and postdates, a large quartz sulphide vein. It consists of angular fragments of altered host rock, up to 2 cm across set in a matrix of black to brown pseudotachylite.

In the Prospector outcrop a major NE-SW brittle fault zone displaces major lithologic units, bedding, foliation, folds and veins. The width of the brittle fault zone is irregular, and ranges up to approximately 20 m. The zone can be followed to the southwest for 150 m. Displacement of the thin sedimentary units (Sherman *et al.*, 1988) suggests a sinistral sense of movement. Small faults dip northwest and have a strike that varies between 210° and 230°.

Pseudotachylite forms fault veins, injection veins and breccia zones similar to that at the FinLay McKinlay zone. Fault veins are most common and vary in width from less than 5 mm to 2 cm, and in length from 10 cm to 1 m. Injection veins, which can be traced to fault veins, have a maximum thickness of 3 cm and length of 50 cm. Breccia zones contain angular fragments in a pseudotachylite matrix. In one breccia zone, angular to rounded fragments that have a maximum size of 2 cm, are set in a matrix of black pseudotachylite.

VEINS

The two vein occurrences in the study area are typical of other occurrences associated with the Johnson Shear Zone. The Prospector veins are hosted by strongly deformed Wasekwan Group rocks and the Finlay McKinlay veins by a foliated Pre-Sickle diorite intrusion.

Prospector veins

The Prospector Veins are typical of vein occurrences in the Wasekwan Group within the study area. The outcrop contains three vein sets:

I) GREEN VEINS

These comprise quartz-carbonate veins that consist of fine grained, granular, white quartz with minor carbonate set in a greenish alteration halo. Individual quartz-carbonate veins are thin (<2 cm), irregular and strongly boudinaged. The alteration halo varies in thickness from 1 to 4 cm and consists of chlorite, epidote, quartz and carbonate.

II) THIN QUARTZ VEINS

This vein set comprises thin veins and pods (<3 cm) in width) of fine grained, granular, highly fractured white quartz with no visible alteration. They are boudinaged and define small scale, F_2 folds.

III) QUARTZ ± SULPHIDE VEINS

These vein sets consists of pods and veins that are much larger than the other two vein sets, and vary in width from less than 10 cm to 3 m and (up to 5 m) in length.

These veins are dominated by highly fractured, coarse grained white to grey quartz with minor carbonate, tourmaline, biotite, chlorite, K-feldspar and sericite(?) Tourmaline occurs as disseminated, fine-to very coarse grained, euhedral, acicular crystals. Pyrite, chalcopyrite, pyrrhotite, arsenopyrite and magnetite are generally present as fine grained disseminations in the adjacent wall rock. Alteration halos consist of chlorite, quartz, biotite, tourmaline, carbonate, garnet and K-feldspar(?). Some veins are boudinaged, and cross-cut vein set II

Finlay McKinlay veins

The Finlay McKinlay Veins contain quartz and quartz-sulphide, hosted by a brittle-ductile shear zone within the Pre-sickle diorite intrusive. The Finlay McKinlay veins comprise three sets:

I) NE-SW TRENDING QUARTZ VEINS

The NE-SW trending veins consist of light grey to yellow-brown, fine-to medium grained quartz with minor tourmaline, biotite, chlorite and K-feldspar(?). Euhedral, black, fine grained crystals of tourmaline occur as disseminations or as irregular masses within the quartz; biotite and chlorite are generally associated with the tourmaline. These veins vary in orientation from 200° to 255° and dip steeply to the NW at more than 75° (Fig. GS-3-1c). Individual quartz veins vary in width from less than 1 cm to 10 cm and in length from 1 to 10 m. Some veins display sigmoidal, south-trending branches. All veins decrease in width toward the southwest and terminate before reaching the Sickle unconformity.

Visible vein related alteration halos comprise medium grained amphibole, and fine grained biotite, chlorite and minor tourmaline. The thickness of these alteration halos ranges from less than 1 cm to 2 cm.

II) N-S TRENDING QUARTZ-SULPHIDE VEINS

The N-S trending veins consist predominantly of grey to white, anhedral, coarse grained, strongly fractured quartz with variable amounts of tourmaline, biotite, chlorite and sulphides. Sulphide mineralogy comprises pyrite and chalcopyrite. The sulphides occur as fracture infillings or as weak disseminations within the adjacent wall rock.

Veins in their vein set in orientation from 160° to 200° with steep dips to the west between 70° to 90° (Fig. GS-3-1c). The veins vary in width from less than 1 cm to 46 cm and are less than 1 m to 7 m in length.

III) QUARTZ-SULPHIDE VEIN

The quartz-sulphide vein occupies the centre of the shear zone and varies in orientation from 219° to 225° and dips to 85° at the northeast. The vein is approximately 12 m a long and varies in width from 8 to 40 cm. Several smaller veins (3 cm to 26 cm wide, that branch to the south bifurcate from the larger quartz-sulphide vein.

The large vein and the smaller branch veins comprise predominantly quartz with significant amounts of tourmaline and minor biotite, chlorite, epidote, and carbonate. Based upon colour and texture, there appears to be two ages of quartz. An early highly fractured coarse- to fine-grained grey to yellow quartz appears to be replaced by a later light to dark grey quartz. Euhedral, fine- to medium-grained, black crystals of tourmaline are associated with biotite and chlorite in massive ribbons or as disseminations in the quartz. Epidote occurs as anhedral, coarse- to medmium-grained light green crystals and carbonate (calcite) was noted along fractures within the quartz.

Internal features in the vein include vein ribbons and a vein breccia. The vein contains several discontinuous vein ribbons that parallel vein walls and contain massive tourmaline and minor biotite. Vein breccia comprises angular, pervasively altered wallrock fragments that have mylonitic texture and a matrix comprising massive tourmaline and quartz.

The quartz-sulphide vein occurs in an intense alteration halo. The halo has a maximum width of approximately 3 m and appears to be vein related. This alteration was documented, in drill core but not observed on surface, displays symmetrical zonation towards the quartz-sulphide vein:

a) pervasive to disseminated K-feldspar-biotite ± chlorite ± pyrite occur away from the vein. The original mylonitic augen have pink K-feldspar rims(?) that appear to selectively replace the original feldspar. Pyrite is disseminated along foliation planes and in pressure shadows of porphyroclasts within the mylonite.

b) a pervasive, narrow zone of chlorite-quartz ± sericite ± carbonate ± epidote occurs farther from the vein. With the exception of quartz-eyes in mylonite, alternation has completely destroyed original textures.

c) massive, strongly fractured to brecciated quartz- tourmaline-carbonate ± pyrite, pyrrhotite and chalcopyrite occurs next to the vein.

d) quartz-sulphide ± carbonate vein.

Significant gold values (up to 0.5 oz/ton) and visible gold (Kelly, 1987) are reported from the quartz-sulphide vein. However, no visible gold has been observed in the present study which suggests that the gold is associated with the sulphides. Pyrite, chalcopyrite, pyrrhotite and sphalerite occur along fractures in the vein or as weak disseminations within the adjacent wallrock alteration zones. Magnetite is massive, anhedral and appears to replace the sulphides.

In general, the N-S quartz-sulphide veins (II) cross-cut NE- SW trending, quartz veins (I). Sulphides are localized along fractures within the N-S trending, quartz-sulphide veins (II) and quartz-sulphide vein (III). This suggests that the two veins sets may be related. Cross-cutting relationships have not been observed between the quartz-sulphide vein that occupies the centre of the shear zone and N-S or NE-SW veins. The three vein sets display brittle deformation.

SUMMARY

The folded and boudinaged nature of the Prospector veins show that emplacement of these veins predates the ductile D_2 and possibly the D_1 deformation events. By contrast, ductile deformation (mylonite formation) at the Finlay McKinlay predates vein formation. Gold mineralization is present only in a late vein set at the Finlay McKinlay and is absent from the Prospector vein set. This indicates that gold precipitation was a late event that occurred after ductile deformation. Although visible gold has been found in this late vein set, the bulk of the gold is probably associated with sulphides. These sulphides occur as fracture infillings or as weak disseminations in wallrock adjacent to the veins. It is therefore possible that gold mineralization occurred after formation of the quartz vein.

The Prospector and the Finlay McKinlay veins have been crosscut by brittle faults. These brittle faults are characterized by the development of pseudotachylite, which is though to form under dry conditions and at relatively shallow crystal levels (< 10 km) (Gibson, 1975). This suggests that hydrothermal activity associated with the shear zone had ceased prior to the formation of the pseudotachylite. In addition, the formation of vesicular pseudotachylite suggests a maximum depth of formation of 2 to 4 km (Allen, 1979). It is suggested that mineralization occurred between the peak of ductile deformation and later, relatively shallow, brittle deformation, and therefore, may have occurred during uplift.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Lynngold Resources, Inc., Manitoba Energy and Mines, Minerals Division and NSERC for financial support. We would like to thank Jim Chornoby and Phil Wright of Lynngold Resources Inc. for their cooperation and assistance. Discussions with Dave Baldwin, Mark Fedikow and Dave Parbery of Manitoba Energy and Mines are appreciated. Finally, we thank Marc Simpson for his assistance in the field.

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GS-4 GEOLOGICAL INVESTIGATIONS IN THE TARTAN LAKE-EMBURY LAKE AREA

by H.P. Gilbert

Gilbert, H.P. 1989: Geological investigations in the Tartan Lake-Embury Lake area; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The Tartan Lake project was initiated in 1986 to provide detailed geological mapping in an area of active base-metal and gold exploration immediately north of the Flin Flon-White Lake map area (Bailes and Syme, 1987, 1989). The major part of the project area has been mapped, with completion this year of coverage to the provincial boundary with Saskatchewan; some parts of the project area to the east are not yet mapped. The main lithologic units mapped to the south (Bailes and Syme, 1987) extend through the Tartan Lake-Embury Lake area, where the major stratigraphic trends change from a dominantly north to north-northwest direction, in the vicinity of Flin Flon to west, between Annabel Creek and Precipice Lake (Fig. GS-4-1 and Preliminary Map 1989F-1).

SUMMARY

Major structural subdivisions have been described previously (Gilbert, 1988; Bailes and Syme, 1989). Mapping this year indicated numerous major faults oriented roughly normal to stratigraphic trends in the Bear Lake and Manistikwan Lake Blocks (Fig. GS-4-1). Strike-slip faults have also been defined or inferred from topographic lineaments throughout the Amisk Group. The layered Tartan Lake gabbro sill (Gilbert, 1987) narrows toward the west margin of the map area whereas the parallel undifferentiated gabbro sill to the south persists into Saskatchewan. A peridotite/pyroxenite lens in the Manistikwan Lake Block in the north part of Embury Lake is tectonically attenuated into several lenses by an inferred strike-slip fault that has been traced through the fault block, with numerous displacements by later north- trending cross faults, from Annabel Creek to the south end of Smook Lake. A unit of polymictic conglomerate extends through the Manistikwan Lake Block close to this fault.

The Manistikwan Lake Fault extends north from the Flin Flon-White Lake area (Bailes and Syme, 1987) to the northwest shore of Embury Lake, intersecting the Embury Lake Fault at the north end of the Cope Lake Block (Fig. GS-4-1). The Cliff Lake tonalite (Bailes and Syme, 1987) extends through the Hook Lake Block and probably terminates close to Annabel Creek just west of the map area. Minor intrusions of tonalite in the northwest part of the map area are probably coeval with the Cliff Lake tonalite. Numerous felsitic units include both Amisk volcanic-related and tonalite-related types. Massive to fragmental felsic volcanic units underlie less than 5 per cent of the map area, but have been identified in all structural blocks of Amisk Group rocks between Tartan Lake and Cliff Lake (Fig. GS-4-1); the largest of these is the 200 m thick fragmental rhyolite unit that hosts the Trout Lake Mine orebody (Ko, 1986).

STRUCTURE

The geology of the Tartan Lake-Embury Lake area is characterized by major folds and faults that trend west or curve northwest to west, in part converging toward the west margin of the map area at Annabel Creek (Fig. GS-4-1, GS-4-2 and Preliminary Map 1989F-1). The major anticline-syncline pair through Tartan Lake cannot be traced further west due to the high degree of strain and lack of top indicators west of Tartan Lake. Limited structural data suggest extension of other major folds west to the provincial boundary, i.e. the syncline through Ruby Lake, the anticline through Smook Lake, the folds at Annabel Creek and the major anticlinal fold inferred through the Hook Lake Block. The northwest-trending anticline in the Cope Lake Block has been better defined by structural data in pillowed basalt, which indicate this fold is subhorizontal, with the axis plunging slightly to the southeast (Fig. GS-4-3); an analogous open syncline through Cope Lake occurs in mafic volcanic flows to the south (Bailes and Syme, 1989).

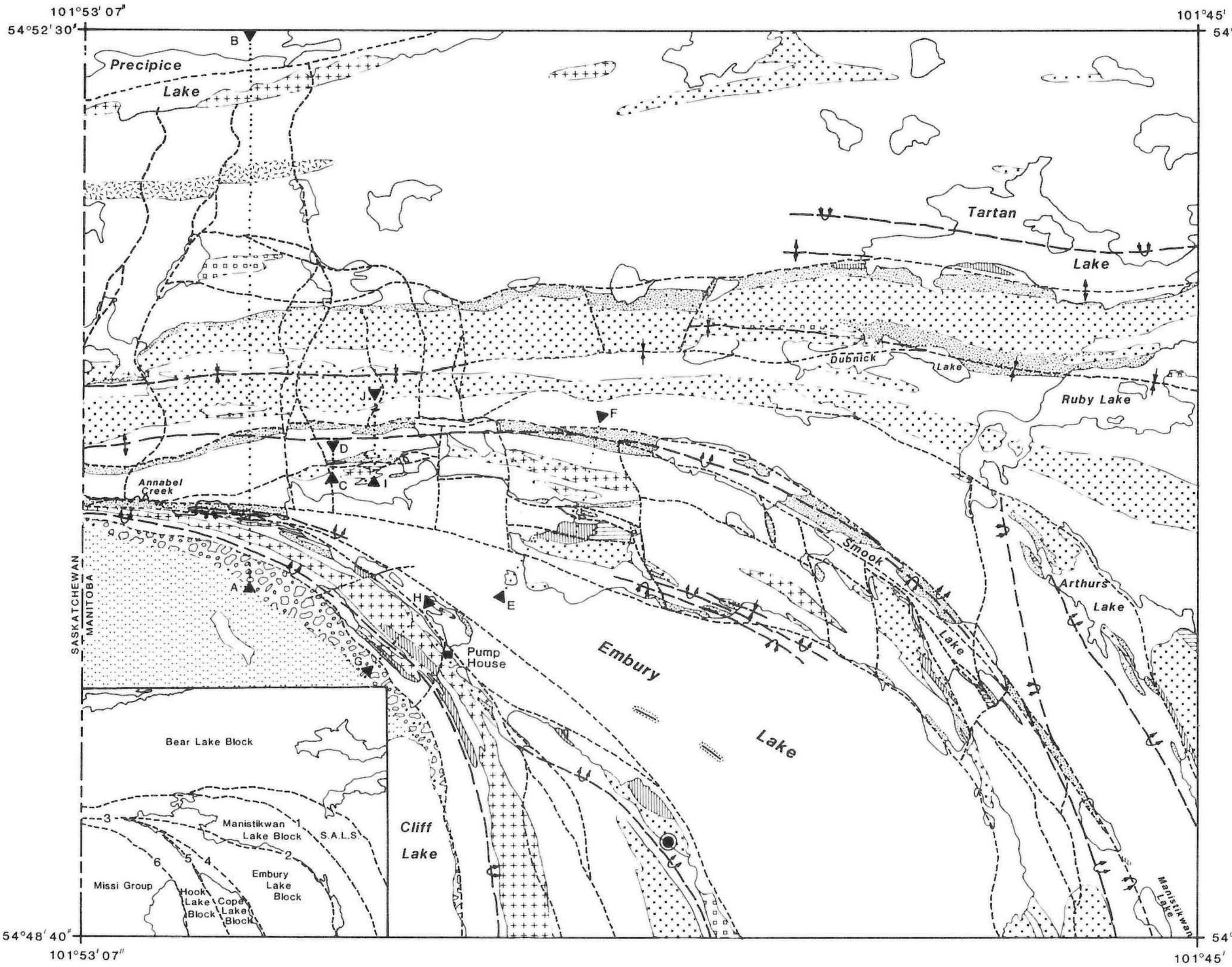
Rocks with a strong planar fabric in the map area (i.e. metasedimentary rocks and well foliated or schistose metavolcanic rocks) commonly display minor folds with strain- slip cleavage resulting from strike-slip movement (Fig. GS-4-4). These minor drag folds deform the regional S1 foliation and thus are F2 or younger in age. The symmetry of the drag folds is not consistent with a genetic relationship to the major folds; there is a preponderance of S-folds in the areas north and west of Tartan Lake, irrespective of which limb of the major folds the minor fold occurs. Furthermore, the sinistral strike-slip movement indicated by the S-folds is the opposite to that which would result from a regional warping of the greenstone belt on the arcuate trend parallel to Embury Lake; rather, the drag folds indicate an east to southeast direction of movement of the greenstone belt relative to the Kisseynew sedimentary gneiss belt to the north (McRitchie et al., 1979). The minor folds and related lineations trend mainly southeast in the northwest part of the project area (Gilbert, 1986; Fig. GS-4-5); the plunge is generally moderate to steep but ranges from vertical to subhorizontal.

Major faults parallel to the regional foliation have been described within and between fault blocks (Bailes and Syme, 1989; Gilbert, 1986, 1987, 1988). The inferred fault through Tartan Lake has been extrapolated west along a prominent topographic lineament. A major fault is also inferred through the Manistikwan Lake Block originating as a branch of the Annabel Creek fault and extending, with later offsets, to Smook Lake (Fig. GS-4-1). This structure envelops a fault slice of altered peridotite and pyroxenite close to the north shore of Embury Lake and is probably associated with considerable vertical displacement because the fault contains a minor (10 m) unit of conglomerate (Fig. GS-4-6) provisionally assigned to the Missi Group and inferred to be down-faulted from a higher stratigraphic level above the present erosional surface (Fig. GS-4-7). North-trending cross faults, that displace this fault, are inferred from topographic lineaments and stratigraphic discontinuities in the Manistikwan Lake Block which is thus subdivided into a series of smaller fault blocks. These are apparently truncated by later movement along the Smook Lake fault to the north (and probably also along the block-bounding fault just offshore to the south). Thus at least three phases of fault movement are indicated; furthermore, the major block-bounding faults may represent relatively early, high-level faults with later reactivation (Bailes and Syme, 1980). The sense of movement on the faults is variable: sinistral oblique-slip movement is inferred along the Annabel Creek fault (Galley, pers. comm.); Bailes and Syme (1989) report dextral displacements of at least 8.5 km and 1.2 km respectively on the Inlet Arm and Cliff Lake faults, and 1.5 km sinistral displacement on the Ross Lake Fault, based on the distribution of metamorphic zones.

Several north-trending cross faults have been defined between Precipice Lake and the Annabel Creek fault by displacement of metasedimentary units and the Tartan Lake gabbro sill, and by prominent topographic lineaments. The trend of the sill has been deflected by sinistral movement along a cross fault that also truncates a zone of felsic porphyry intrusions within the mafic volcanic rocks further north, close to the provincial boundary. Field evidence for the major faults includes localized development of fracture cleavage, cataclasite or schist, commonly with carbonatization; these features are variously developed in rocks close to major faults, whereas the faults themselves are more commonly obscured by topographic lows.

STRATIGRAPHY

The Bear Lake Block, which has been described by Bailes and Syme (1989) and Gilbert (1987, 1988), consists largely of basaltic andesite, up to 2.9 km thick, intruded by large gabbroic sills accounting for approximately 30 per cent of the block (Fig. GS-4-8). Subordinate fine grained volcanogenic sedimentary rocks are intercalated with and overlie the mafic volcanic rocks in the upper part of the section. The tuffaceous sediments (up to 330 m thick) are best developed between Dubnick and Tartan lakes where they have been invaded by the Tartan Lake gabbro



LEGEND

- SERPENTINIZED PERIDOTITE, PYROXENITE, HORNBLENDITE
- MISSI GROUP
  - SANDSTONE, PEBBLY SANDSTONE
  - CONGLOMERATE
- TONALITE ± QUARTZ-EYES, QUARTZ DIORITE, GRANODIORITE
- QUARTZ-PLAGIOCLASE PORPHYRY, FELSITE, LEUCOTONALITE
- HORNBLENDE QUARTZ DIORITE
- GABBRO, MELAGABBRO, DIORITE; MINOR HORNBLENDITE AND SCHIST
- AMISK GROUP
  - GREYWACKE, SILTSTONE, MINOR ARGILLITE, CONGLOMERATE AND SCHIST
  - FELSIC AND INTERMEDIATE FLOWS, RELATED INTRUSIVE AND FRAGMENTAL ROCKS
  - MAFIC AND INTERMEDIATE FLOWS, RELATED INTRUSIVE AND FRAGMENTAL ROCKS; DERIVED SCHIST AND GNEISS

SCALE

0 1 2 3 4 Kilometres

SYMBOLS

- INFERRED MAJOR FAULT
- AXIAL TRACE OF ANTICLINE (UPRIGHT, OVERTURNED)
- AXIAL TRACE OF SYNCLINE (UPRIGHT OVERTURNED)
- TROUT LAKE MINE
  - Cu-Zn SULPHIDE OREBODY (SURFACE PROJECTION)
  - MINE PORTAL
- SECTION LINES IN FIGURES GS.-4-2, 7, 11, 15 AND 17

1	SMOOK LAKE FAULT	4	EMBURY LAKE FAULT
2	BIG ISLAND FAULT	5	MANISTIKWAN LAKE FAULT
3	ANNABEL CREEK FAULT	6	CLIFF LAKE FAULT

S.A.L.S. SMITH-ARTHURS LAKES SECTION

Figure GS-4-1: Geology and major structural elements of the Tartan Lake-Embury Lake area.

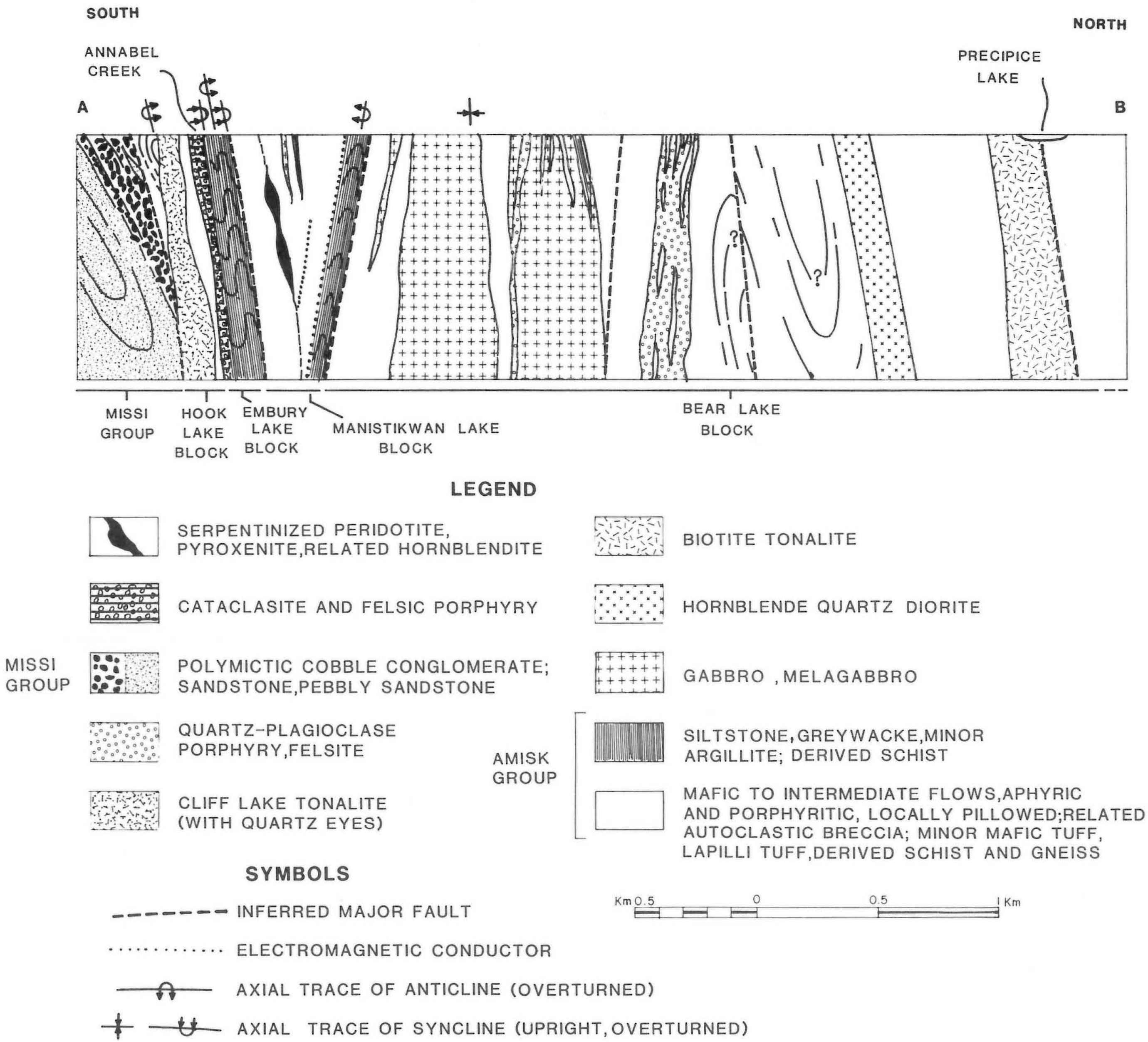
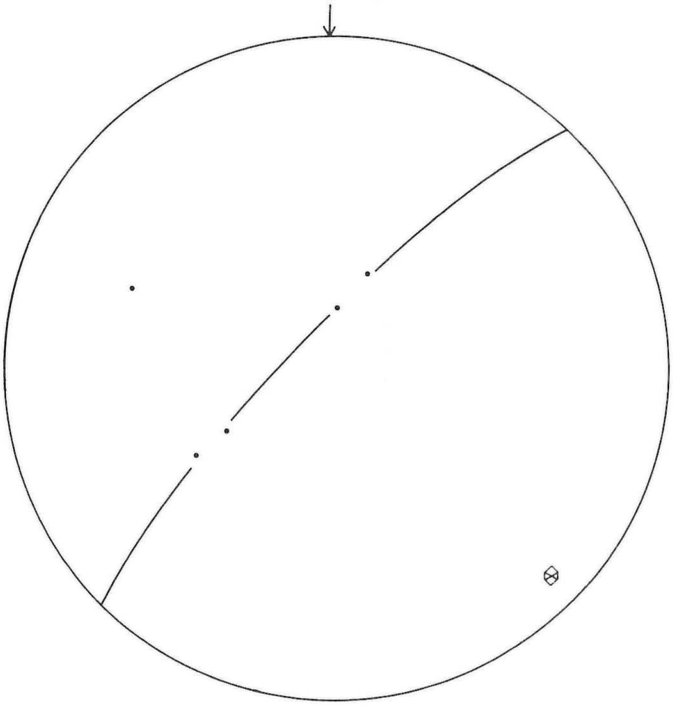


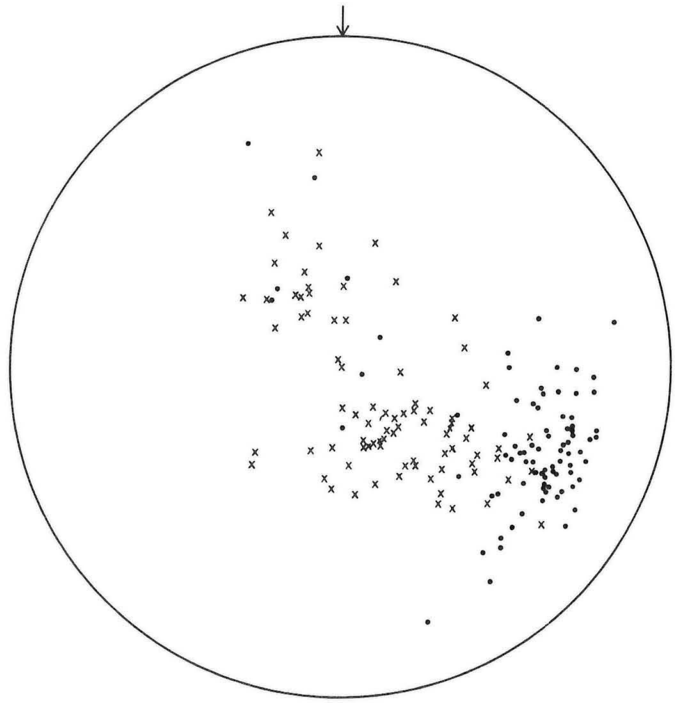
Figure GS-4-2: *Transverse section through part of the Flin Flon volcanic belt from Precipice Lake to the area northwest of Cliff Lake. AB section line is shown in Figure GS-4-1.*



• Pole to pillowed basalt flow

⊗ Inferred major fold axis

Figure GS-4-3: *Lower hemisphere stereographic plot of poles to pillowed basalt flows in the axial zone of the overturned anticline through the north part of the Cope Lake Block.*



× Minor fold axis

• Lineation

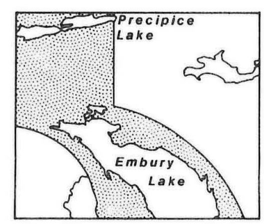


Figure GS-4-5: *Lower hemisphere stereographic plot of minor fold axes and related lineations in the area between Precipice Lake and the north part of Embury Lake; data are from the shaded area on the inset map.*

Figure GS-4-4: *Minor fold with strain-slip cleavage in mafic schist/tonalite section close to the north shore of Embury Lake.*

Figure GS-4-6: Oligomictic cobble conglomerate interpreted as a downfaulted outlier of Missi Group rocks, close to the northwest end of Embury Lake.

sill; the sedimentary unit thins westward to the provincial boundary, where it consists of minor units (35 m, 20 m thick) flanking the gabbro sill. The westward stratigraphic thinning is accompanied by a tectonic thinning indicated by the generally high level of strain in the mafic volcanic section between Tartan Lake and Precipice Lake, where the flows range from moderately deformed (Fig. GS-4-9) to highly attenuated and altered to amphibolitic laminated gneiss and chloritic schist (Fig. GS-4-10). Felsitic units and related porphyry, which are abundant over a 500 m wide zone within the mafic volcanic section south of Precipice Lake, are provisionally interpreted as minor intrusives of the Amisk Group; a 150 m wide quartz diorite sill in mafic flows to the north may also represent a subvolcanic intrusion.

The Manistikwan Lake Block in the Tartan Lake-Embury Lake area (Gilbert, 1988) is reinterpreted as a southwest facing, monoclinal section (Fig. GS-4-11) except for an anticline that extends from Smook Lake south-southeast along the west side of Manistikwan Lake. This interpretation is based on only ten top indicators spaced widely within the block, but is consistent with the structure of the Manistikwan Lake Block in the Flin Flon-White Lake area (Bailes and Syme, 1989). Folds have been mapped in flanking sedimentary rocks to the southwest (probably part of the Embury Lake Block - Gilbert, 1988) and in similar rocks in the fault slice extending through Smook Lake to the northeast; an anticline has been mapped through the fault slice and beyond into the Manistikwan Lake Block along the north margin in the area north of Embury Lake.

The Manistikwan Lake Block is lithologically diverse, although basalt is the predominant lithology (Fig. GS-4-11). Differences in mafic volcanic flow lithology from the Bear Lake Block have been described (Gilbert, 1988). An additional distinction is the occurrence of a 90 m thick unit of intermediate to mafic volcanic fragmental rocks of probable pyroclastic origin at Smook Lake and to the southeast, within the mafic volcanic flow section. These fragmental rocks locally underlie and may in part be related to a polymictic, volcanogenic conglomerate unit (at least 45 m thick) that occurs in the central part of the section (Fig. GS-4-11; GS-4-12) and has been mapped in localized occurrences from the north shore of Embury Lake to the south end of Smook Lake. The conglomerate is overlain by mafic volcanic rocks that in turn are overlain by a 30-40 m thick unit of felsic tuff, lapilli tuff and related massive volcanic rocks at Smook Lake. Abundant minor intrusions of felsite and felsic porphyry in the north end of the Manistikwan Lake Block may be related to the felsic fragmental unit at Smook Lake and massive felsic volcanic rocks at an equivalent stratigraphic level at the north shore of Embury Lake (Fig. GS-4-1). Abundant minor dykes and lensoid bodies of quartz-eye tonalite, up to 120 m wide, in the Manistikwan Lake Block north of Embury Lake are possibly contemporaneous with the Cliff Lake tonalite (Bailes and Syme, 1989). Serpentinized peridotite, associated with pyroxenite and related hornblendite occurs as lenses up to 150 m thick that are interpreted as fault-bounded at the south end of Smook Lake, just west of the north end of Smook Lake, and at the north end of Embury Lake. A 20 m wide unit of quartz-filled intrusion breccia is associated with faulting at the south margin of the largest (150 m thick) ultramafic lens close to the north shore of Embury Lake. Carbonatization and alteration of adjacent host-rocks are characteristic of the ultramafic intrusions; rare primary layering is locally preserved (Fig. GS-4-13). The association of these intrusions with major faults suggests either tectonic emplacement or intrusion up faults, which implies a syn- or post-faulting age.

The Embury Lake Block is terminated at the provincial boundary by the convergence of the Big Island and Embury Lake faults at Annabel Creek (Fig. GS-4-1). Graded, fine grained sedimentary rocks close to this termination are very well preserved (Fig. GS-4-14). Stratigraphic details of this predominantly metasedimentary sequence are described by Gilbert (1988); the Trout Lake Mine section, containing parts of the Embury Lake and Cope Lake blocks, is described by Ko (1986).

The Cope Lake Block is composed mainly of aphyric and plagioclase-phyric basalt that is commonly pillowed and associated with gabbro and leucogabbro. Lithologic gradation with basalt indicates a synvolcanic age for some gabbro units. Subordinate mafic autoclastic breccia is widespread, but at one locality near the north end of the fault block volcanic breccia had previously been mapped as an outlier of Missi Group conglomerate (Tanton, 1941).

Mafic volcanic flows are overlain to the northeast by a 50 m thick unit of massive rhyolite with subordinate fragmental zones. A gabbro to melagabbro sill is emplaced partway along the mafic/felsic volcanic contact. Minor metasedimentary units, up to 12 m thick, occur immediately below and within the felsic volcanic rocks; these include greywacke and siltstone (locally porphyroblastic), subordinate conglomerate and minor chert. Minor intrusions of quartz and diabase, ankeritic veins and carbonatization occur in the contact zone between the mafic and felsic volcanic rocks; faulting has locally resulted in the development of chloritic and sericitic schists and tectonic breccia in the contact zone. The block-bounding Embury Lake Fault extends offshore along the northeast margin of the felsic volcanic unit, which is at least 180 m wide (Ko, 1986); only 55 m of the unit are exposed at the shore of Embury Lake, close to the mine

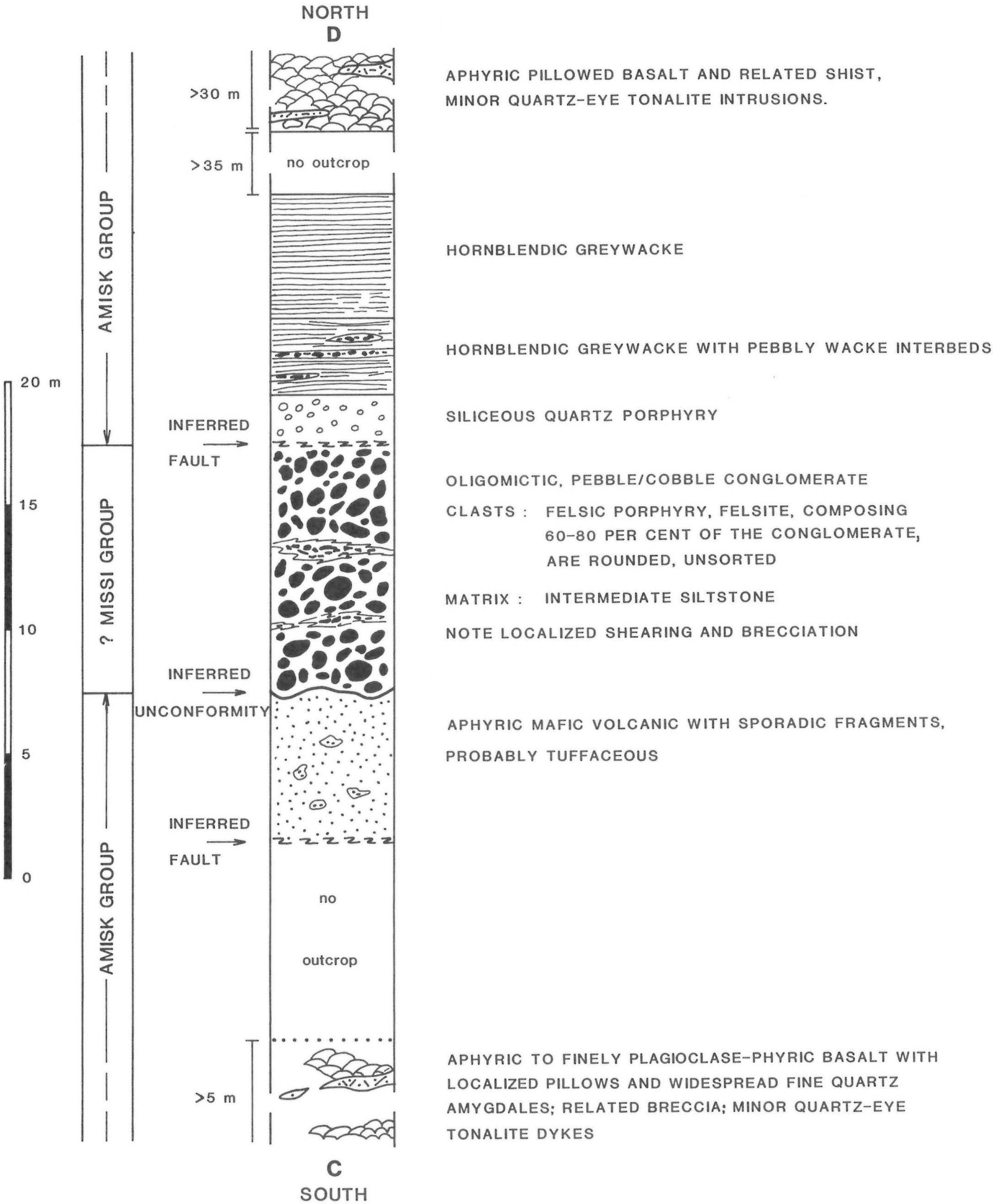


Figure GS-4-7: *Stratigraphic section through the inferred fault slice of Missi conglomerate close to the northwest end of Embury Lake. CD section line is shown in Figure GS-4-1.*

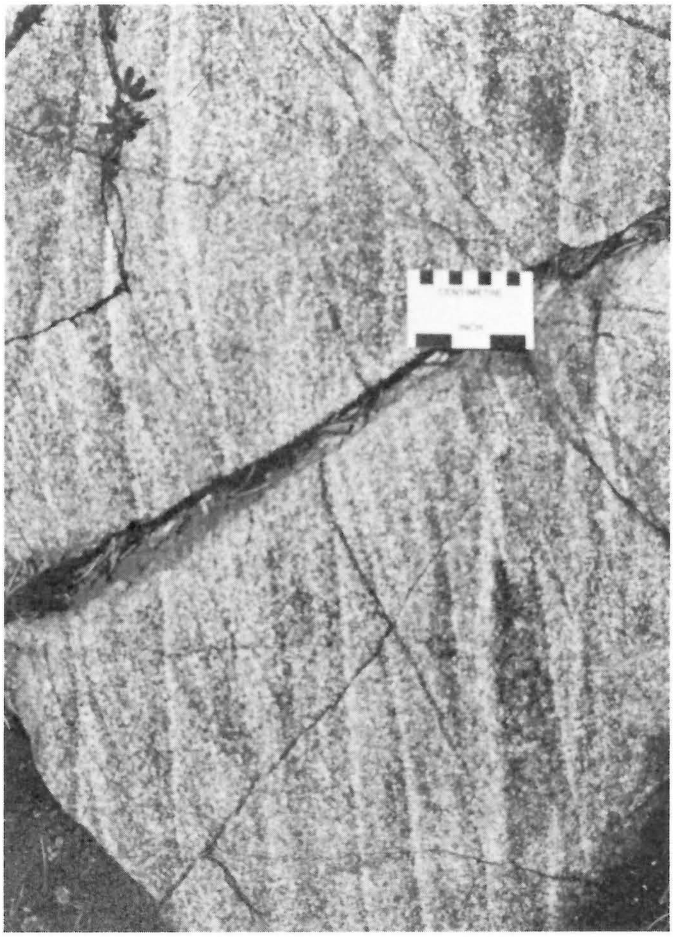


Figure GS-4-8: *Massive gabbro with diffuse igneous layering typical of the mafic sill that extends through the south part of Ruby Lake.*

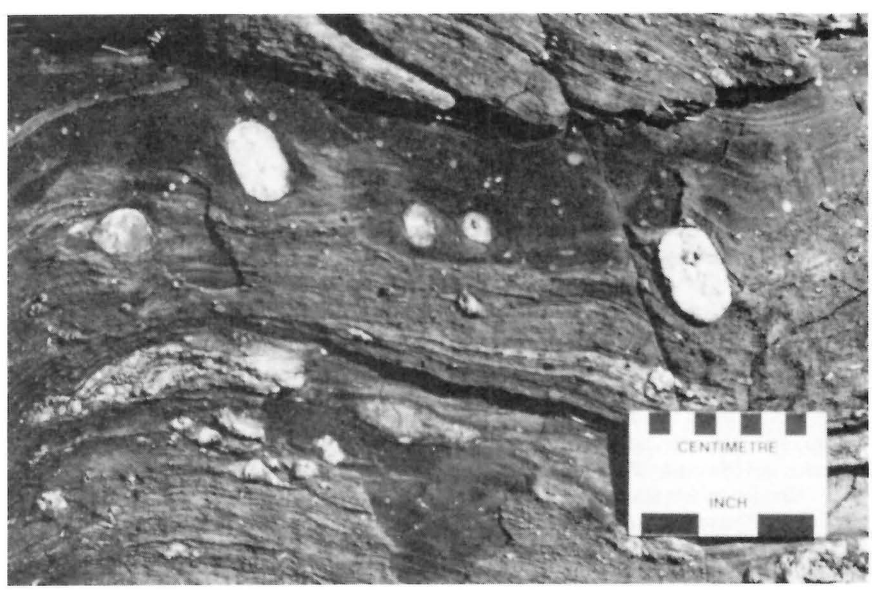
portal of Trout Lake Mine. No significant mineralization was observed in the shoreline exposure.

The Hook Lake Block (Bailes and Syme, 1989) extends along the southwest side of the north part of Embury Lake, where the section is dominated by aphyric and porphyritic mafic volcanic rocks consisting of massive and pillowed flows and equally abundant amygdaloidal breccia. These rocks are pervaded by tonalite (variously quartz-phyric) and subordinate granodiorite that compose the northern extension of the Cliff Lake tonalite, which occupies much of the central zone of the fault block in the area west of Embury Lake. The tonalite contains sporadic skialithic enclaves of basalt and has locally caused intense silicification of basalt in contact zones. The tonalite is locally truncated by late faults (e.g. in the north end of the Hook Lake Block) and is thus interpreted to be older than the ultramafic intrusions in the Manistikwan Lake Block, which are apparently contemporaneous with or later than the late faults. Northwest-trending diabase dykes (altered to amphibolite) occur sporadically in the tonalite east of Cliff Lake. The northwest-trending anticlinal fold through the Hook Lake Block (Fig. GS-4-1) is inferred from very limited structural data; the west-facing monoclinal section established for the fault block further south (Bailes and Syme, 1989) would compose the west limb of the proposed fold. Mafic volcanic flows and flow-breccia occupy the axial zone of the anticline north of Cliff Lake (Fig. GS 4-15). The basaltic rocks are overlain to the northeast by a 65 m wide massive to fragmental felsic volcanic unit that extends laterally for 1 km. Equivalent felsic volcanic rocks on the southwest limb of the fold are overlain by:

1. conglomerate (30 m) containing clasts of fine grained greywacke and siltstone in an argillitic siltstone matrix;
2. amygdaloidal basalt and pillowed basalt (10 m); and
3. mafic tuff and lapilli tuff (55 m) that compose the uppermost volcanic unit; this unit has apparently been removed by erosion at the northwest end of the Hook Lake Block, prior to deposition of the overlying Missi Group conglomerate. A 35 m thick unit of coarse heterolithologic breccia (Fig. GS-4-16) is on-strike with the mafic tuff unit close to the south margin of the map area.

The unconformable contact between the Amisk Group and Missi Group in the area north of Cliff Lake is commonly sharp and free of alteration in contrast to the occurrence of spheroidally weathered and altered regolith at the unconformity in the Flin Flon area (Bailes and Syme, 1989). In that area, the contact is coincident with the Cliff Lake Fault, which has been extrapolated northwest along the unconformity to the vicinity of Annabel Creek; local departures of the fault from the unconformity probably occur because several exposures of that contact are devoid of shearing. The basal Missi conglomerate is intercalated with lensoid units of

Figure GS-4-9: *Moderately deformed, aphyric pillowed basalt with quartz amygdales up to 5 cm across in the Embury Lake-Precipice Lake section.*



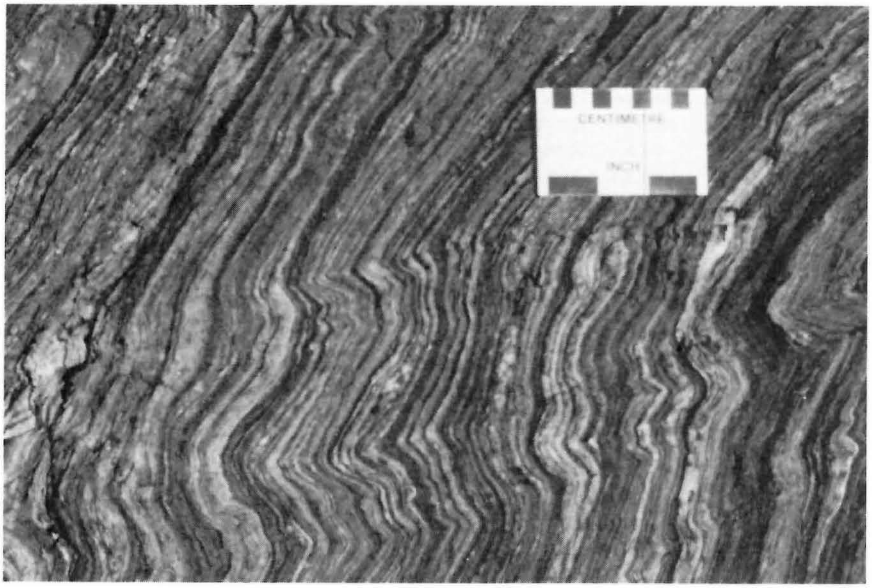


Figure GS-4-10: Laminated gneiss and schist derived from pillowed basalt, just north of Embury Lake.

arkosic wacke up to 5 m thick. Bedding in the west-facing Missi rocks at Cliff Lake dips at moderate angles to the east, consistent with the overturned synclinal structure mapped in the Missi Group further south (Bailes and Syme, 1989).

ECONOMIC GEOLOGY

The most significant mineralization encountered this season occurs in a 38 m thick unit of argillitic sedimentary rocks structurally underlying fault-bounded ultramafic lenses at the north end of Embury Lake (Fig. GS-4-1). The mineralized unit is probably equivalent to a unit of fine grained sedimentary rocks on the opposite limb of a major anticline (Fig. GS-4-17). The mineralized section on the south limb consists of highly foliated argillitic siltstone, associated with slaty argillite and siliceous siltstone; sulphides are oxidized resulting in extensive iron-staining, but a thin (1 m) chloritic amphibolite unit at the base of the sedimentary section contains 10-15 per cent pyritohedra up to 5 mm across. Minor felsitic units and localized carbonatization are characteristic of the mineralized zone; greywacke and minor pebble-conglomerate occur downstrike from this zone.

The sedimentary units on both north and south limbs of the anticline (Fig. GS-4-17) are associated with electromagnetic (EM) conductors (cancelled assessment data, Hudson Bay Exploration and Development Company). The sedimentary unit on the north limb of the fold is marked by an EM conductor which extends intermittently along the north and northeast margin of the unit from Saskatchewan in the west to Manistikwan Lake at the south margin of the map area; most of this contact corresponds to the Smook Lake fault, interpreted as a branch of the Inlet Arm Fault to the south (Bailes and Syme, 1989). The occurrence of a felsic volcanic unit close to this fault just north of Manistikwan Lake may be significant to further investigation of the EM anomaly (Gilbert, 1988).

The stratigraphy of the Trout Lake Mine (Ko, 1986) shows the Cu/Zn orebody is hosted by felsic volcanic fragmental rocks within a section of argillitic sedimentary rocks. One of the few felsic volcanic deposits in the map area occurs in the Hook Lake Block just north of Cliff Lake: the 25 m thick felsic unit (Fig. GS-4-18) is overlain by a 30 m thick unit of conglomerate with an argillitic siltstone matrix (Fig. GS- 4-15); no surface showings were encountered in the felsic fragmental unit, although there is a similarity between this section and the setting of the Tartan Lake Mine orebody (Ko, 1986). The orebody, however, is in the Embury Lake Block; stratigraphic relationships between major fault blocks in the Flin Flon belt are unknown (Bailes and Syme, 1989).

Minor sulphide showings were mapped within basalt of the Hook Lake Block. These occur as pyritic stringers and/or disseminated pyrite, and are associated with silicification and localized pervasive epidotic veining. These showings are located adjacent to minor dykes of felsite or plagioclase ($\pm$ quartz) porphyry. Locally, sulphides occur in the felsitic dykes.

The recognition of extensive cross faulting, especially in the Manistikwan Lake Block, and several intra-block faults, parallel or oblique to stratigraphic trends is significant for potential base-metal or gold mineralization. The intersection of these faults with other major structures, or with mineralized stratigraphic units, may have locally resulted in the occurrence of favourable environments for ore formation.

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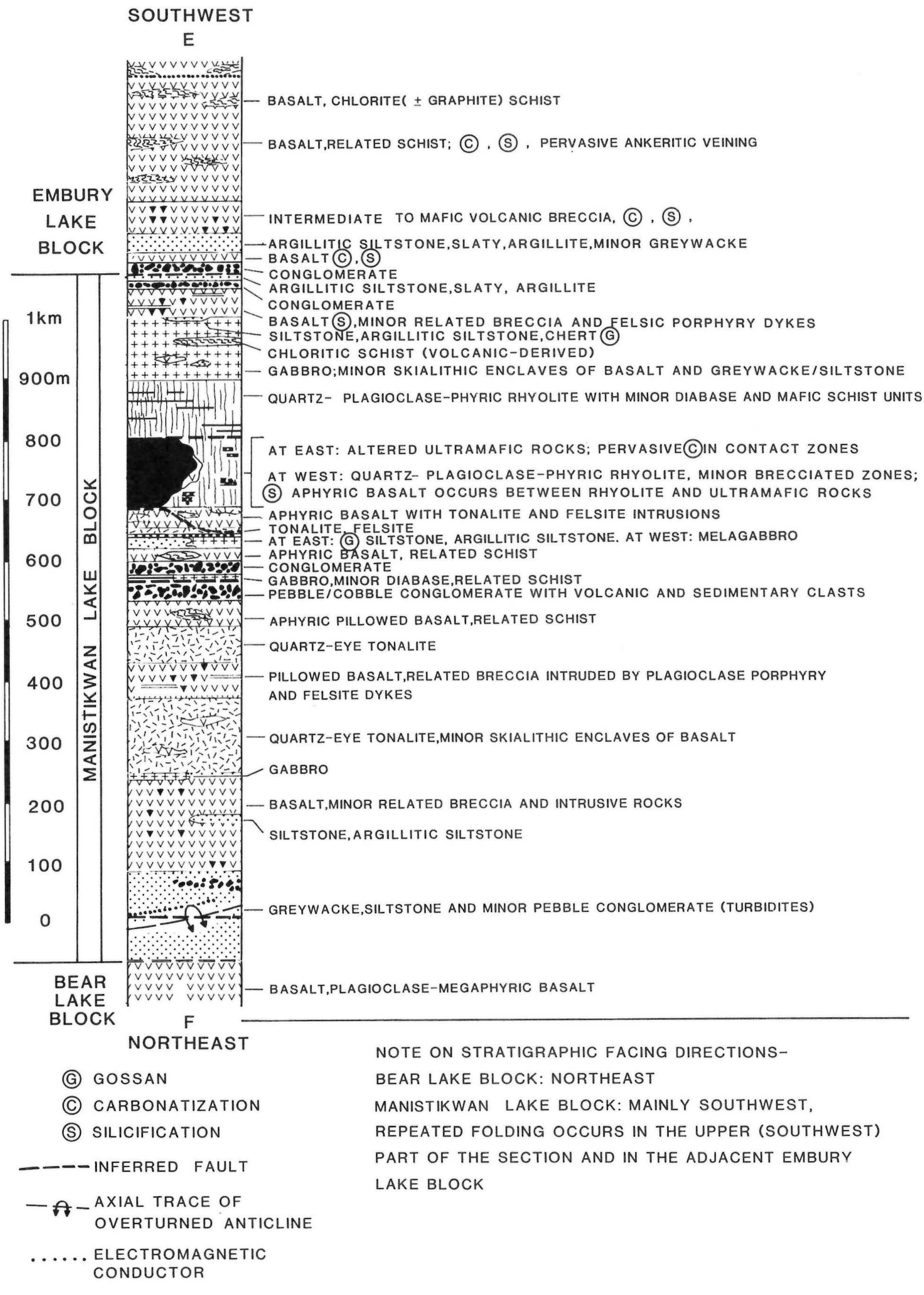

Figure GS-4-11: Stratigraphic section through the Manistikwan Lake Block in the north part of Embury Lake. EF section line is shown in Figure GS-4-1.

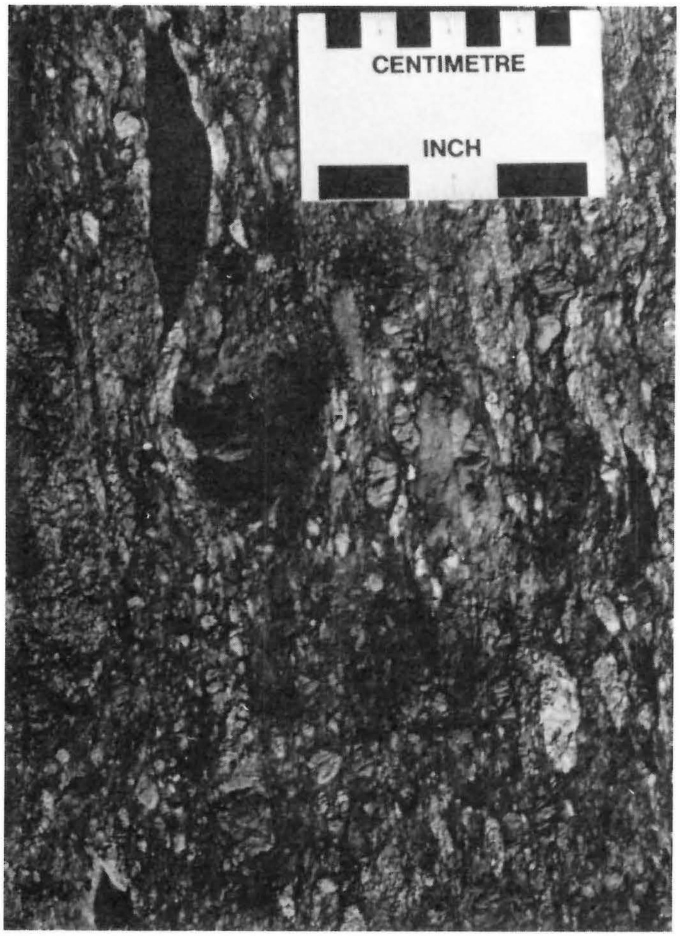

Figure GS-4-12: *Polymictic pebble/cobble conglomerate in the Manistikwan Lake Block at Smook Lake.*

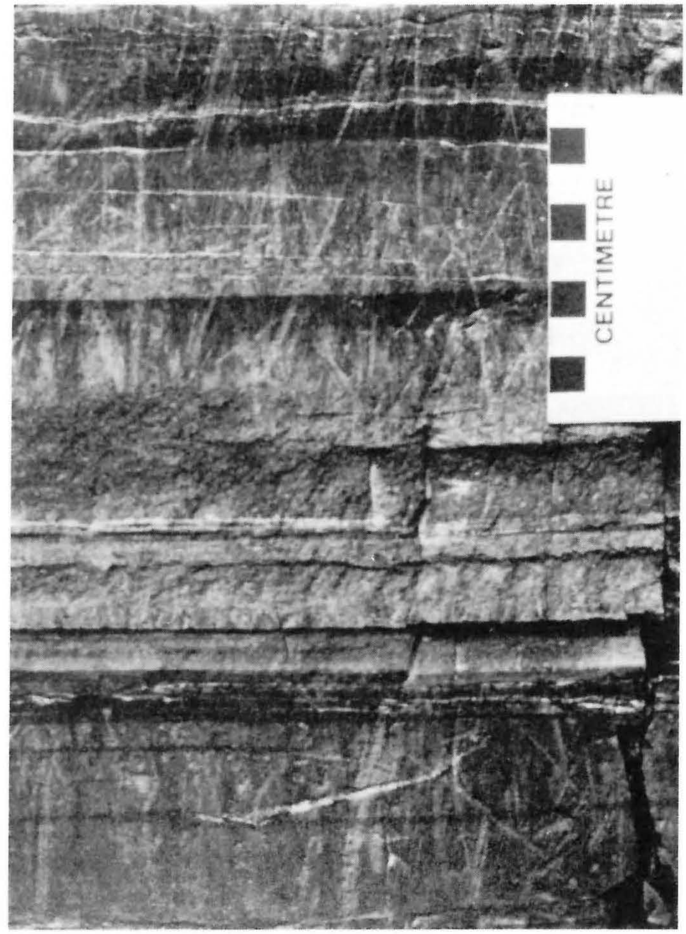

Figure GS-4-14: *Graded, fine grained, sedimentary rocks at Annabel Creek, close to the west end of the Embury Lake Block.*

Figure GS-4-13: *Serpentinized peridotite with igneous layering at the south margin of the 150 m thick ultramafic lens close to the north shore of Embury Lake.*

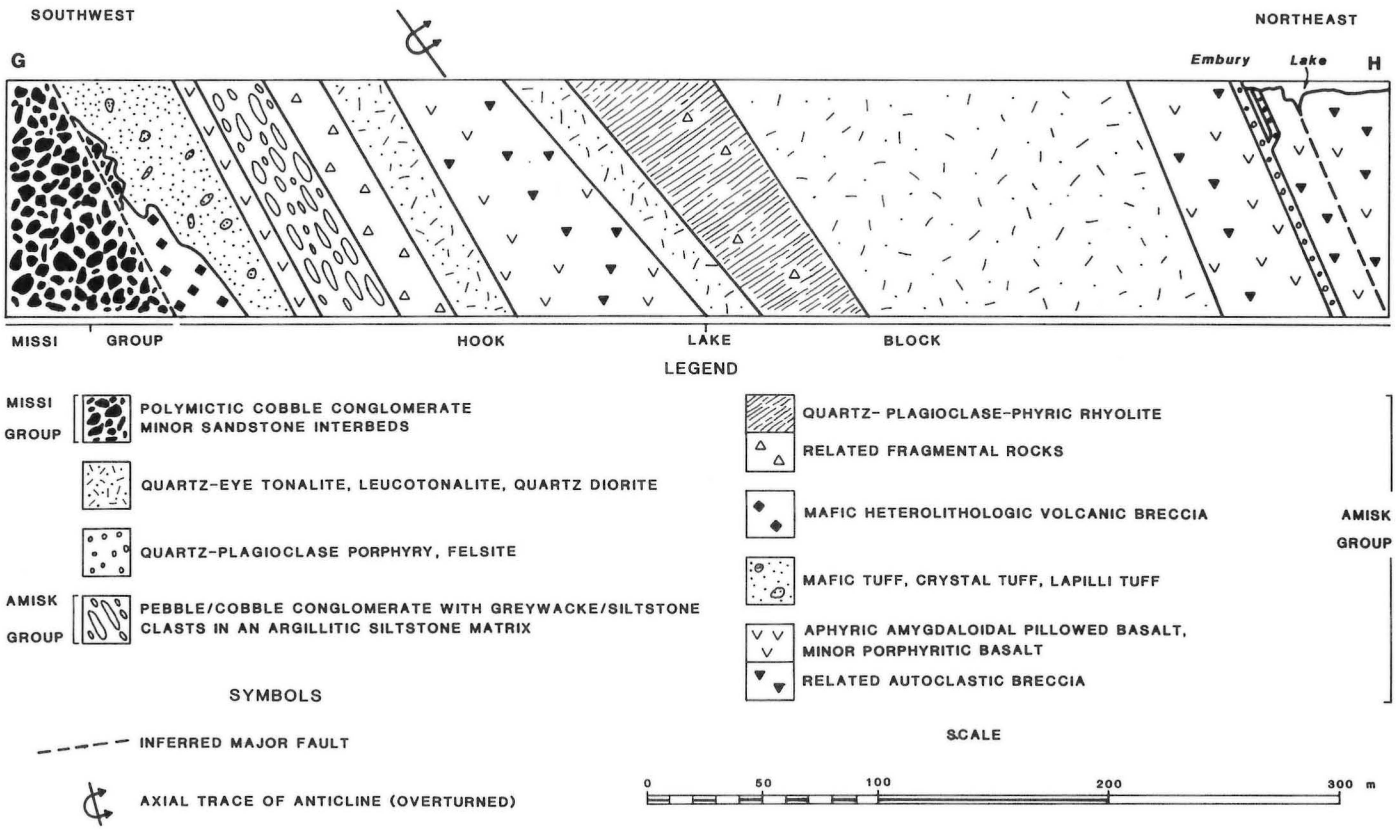

Figure GS-4-15: Transverse section through the Hook Lake Block, just west of the pump house at the west shore of Embury Lake. GH section line is shown in Figure GS-4-1.

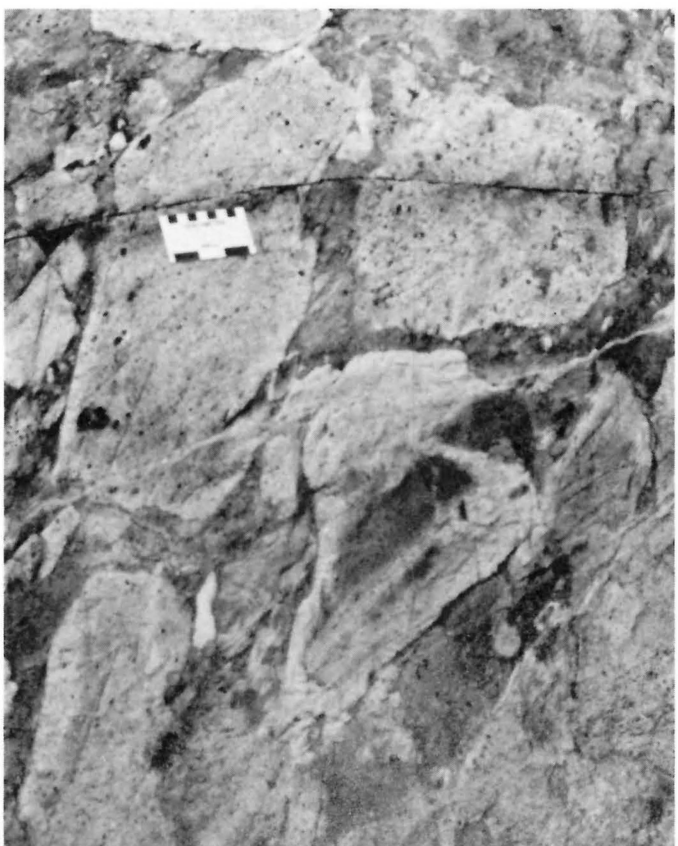

Figure GS-4-16: Heterolithologic volcanic breccia in the Hook Lake Block east of Cliff Lake, close to the eroded upper margin of the Amisk Group.

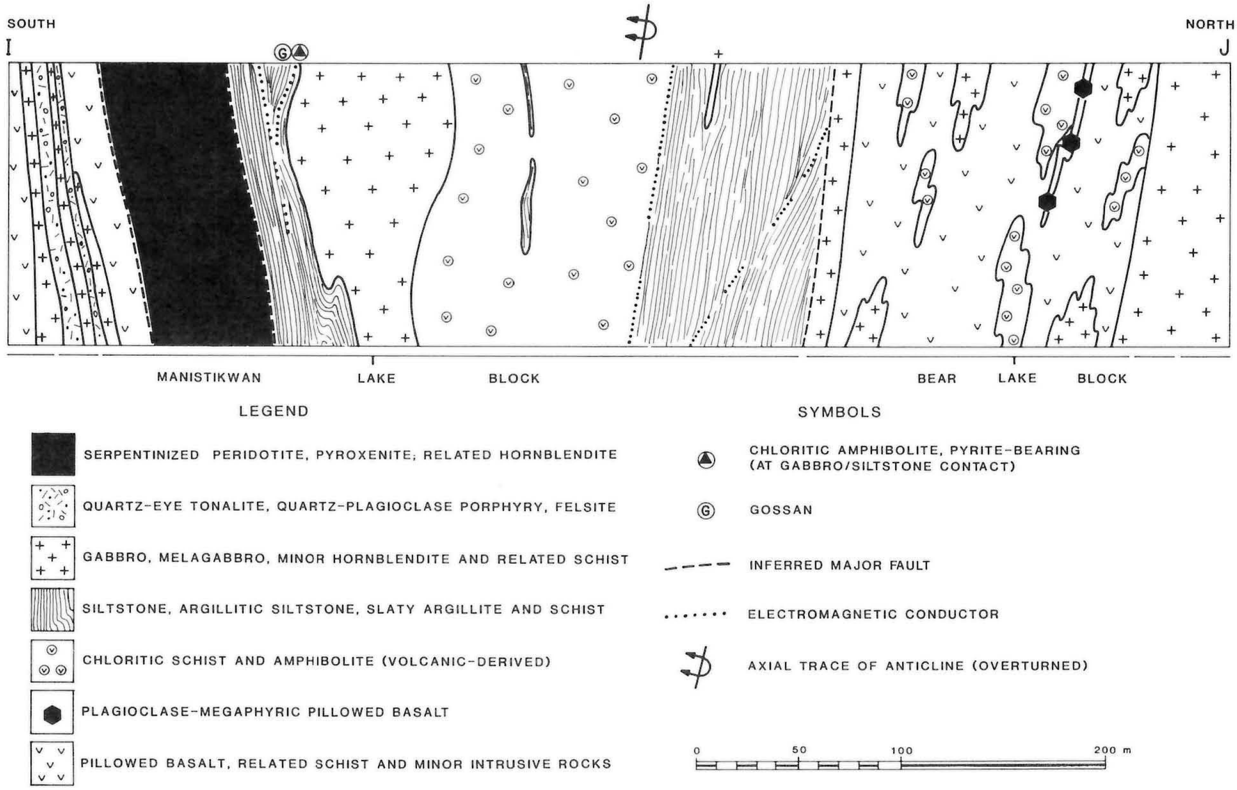

Figure GS-4-17: *Transverse section through the lower part of the Manistikwan Lake Block near the northwest end of Embury Lake, containing a 38 m unit of mineralized argillitic rocks. IJ section line is shown in Figure GS-4-1.*

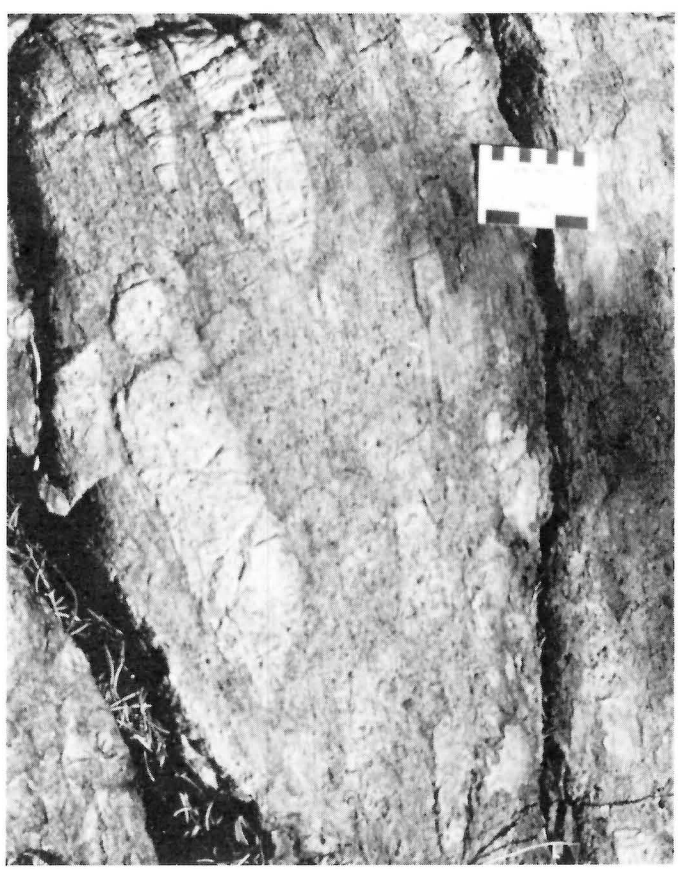

Figure GS-4-18: *Felsic volcanic fragmental rocks in the Hook Lake Block, north of Cliff Lake.*

GS-5 GEOLOGICAL SETTING OF AND HYDROTHERMAL ALTERATION BELOW THE CHISEL LAKE MASSIVE ZN-CU SULPHIDE DEPOSIT

by A.H. Bailes and A.G. Galley[1]

Bailes, A.H. and Galley, A.G. 1989: Geological setting of and hydrothermal alteration below the Chisel Lake massive Zn-Cu sulphide deposit; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

In 1989 detailed mapping was undertaken jointly by the provincial and federal governments in the Chisel Lake area. Main objectives of this project are to provide an improved geological data base for future mineral exploration and to gain a better understanding of the depositional environment of the base metal sulphide deposits and their relationship to an areally extensive alteration zone. Similar joint provincial-federal studies will be undertaken for other Snow Lake area base metal deposits in conjunction with federal EXTECH programs slated for implementation in the 1990 field season.

The Chisel Lake area was mapped at 1:5 000 scale during a one month field program (Preliminary Map 1989S-2). This map incorporates previous 1:2 000 mapping of the Edwards Lake area (Skirrow, 1987; Skirrow and Franklin, 1989) and 1:15 840 mapping of the Chisel Lake pluton (J. Young, pers.com.1987). A mapping scale of 1:5 000 was chosen as it is adequate to show most of the lithologic units and alteration features. Detailed 1:1 000 scale mapping of the Chisel Mine open pit was done in conjunction with this mapping and is reported elsewhere in this volume (Galley and Bailes, 1989).

GEOLOGICAL SETTING OF THE CHISEL LAKE DEPOSIT

A sequence of Amisk Group metavolcanic rocks, approximately 3 km thick, is exposed in the project area (Figs. GS-5-1 and 2; Table GS-5-1). The Chisel Lake, Lost Lake, Ghost Lake and Chisel North Zn-Cu deposits occur near the top of this sequence. The rocks and contained ore deposits are deformed by northwest-trending F_1 and north-northeast-trending F_2 folds and have been recrystallized to almandine amphibolite facies mineral assemblages during a post-folding regional metamorphic event. In the vicinity of the Chisel Lake, Lost Lake and Ghost Lake deposits F_1 and F_2 folds interfere to produce shallow dips and structural repetition of the section. To the south of the deposits Amisk rocks are monoclinal and top and dip steeply to moderately to the north.

Amisk Group volcanic rocks in the Chisel Lake area are extensively altered (Fig. GS-5-3; Preliminary Maps 1989-S1 & S2). This alteration has been attributed to a large-scale hydrothermal system that was active during formation of volcanogenic base metal sulphide deposits (Walford and Franklin, 1982; Bailes, 1986, 1987; Bailes *et al.*, 1987). They proposed that the heat source for the hydrothermal system was synvolcanic tonalite intrusions such as the Sneath Lake and Richard Lake plutons (Fig. GS-5-1). A U-Pb age of 1889 +8/-6 Ma (Bailes *et al.*, 1988) for the Richard Lake tonalite, comparable to a U-Pb age of 1886 +/-2 Ma on an Amisk Group rhyolite tuff (Syme *et al.,* 1987) from Flin Flon, is consistent with this interpretation. The absence of substantive hydrothermal alteration in volcanic rocks overlying the Chisel-Lost-Ghost lakes base metal sulphide zone (Fig. GS-5-3; Preliminary Map 1989S-2) supports a synvolcanic age for the alteration.

Mafic volcanic rocks in the Chisel Lake area display arc tholeiite chemistry and are similar to basalt and basaltic andesite sequences that host base metal deposits at Flin Flon (Syme, in press; Bailes, 1988). Both the Chisel Lake and Flin Flon mafic lavas are enriched in LIL (light ion lithophile) elements and moderately to strongly depleted in HFS (high field strength) elements, a feature characteristic of subduction related magmas (Saunders *et al.*, 1980; Gill, 1981; Tarney *et al.*, 1981).

The Chisel Lake, Lost Lake and Ghost Lake Zn-Cu massive sulphide deposits occur at the top of a chemically distinct fractionated mafic to felsic sequence that consists of the Moore Lake basalt, the Powderhouse dacite and the Ghost Lake rhyolite (Fig. GS-5-2; Table GS-5-1). The fractionated Moore Lake basalt is distinctly different from other mafic flow units in the project area as it has high incompatible element and elevated light REE (rare earth element) abundances plus low Ni and Cr (Bailes, 1988). The overlying Powderhouse dacite and Ghost Lake rhyolite display similar high incompatible element and elevated light REE abundances, distinguishing them from other felsic volcanic rocks in the Chisel Lake area (Bailes, 1988).

[1]Geological Survey of Canada

TABLE GS-5-1
STRATIGRAPHY OF THE CHISEL LAKE SECTION

Thickness (metres)	Unit No. (Figure GSC-5-2)	Lithology (Names of units are informal)
400	11	**Chisel basin mafic tuff, tuff breccia, lapilli tuff and wacke**, minor pillowed porphyritic basalt flows; well stratified with turbidite bedforms and local accretionary lapilli
0-30		**Massive Zn-Cu sulphides** (Chisel- Lost-Ghost zone)
0-300	10	**Ghost Lake aphyric and sparsely quartz- and plagioclase-phyric rhyolite flows**
0-100	9	**Aphyric basalt flows**, mainly massive
50-300	8,8a	**Powderhouse plagioclase-phyric dacite tuff and lapilli tuff**, minor stratified heterolithic breccia and wacke
250-600	7	**Moore Lake basalt and basaltic andesite flows and amoeboid pillow breccia**, characterized by high vesicularity and radial pipe vesicles; includes minor plagioclase-phyric mafic flows and intercalated monolithologic and heterolithologic mafic breccia
0-150	6	**Caboose andesite**, mainly massive flows
300	5	**Edwards Lake heterolithologic volcanic wacke**, minor intercalated mafic wacke; stratified with 1 to more than 35 m thick beds; includes mafic and felsic debris with mafic detritus more prominent
0-300	5a	**Edwards Lake mafic volcanic wacke** and minor breccia
200-700	4	**Snell Lake plagioclase- and plagioclase-pyroxene-phyric massive and pillowed basalt and basaltic andesite flows**; flows are up to 100 m thick
100-400	3,3a	**Stroud Lake stratified heterolithic and monolithic felsic breccia and wacke** with intercalated units of intermediate to mafic greywacke, siltstone and mudstone, local strong gossan zones
0-750*	2	**Daly Lake quartz-phyric, quartz- plagioclase-phyric and aphyric subaqueous rhyolite flows**, minor breccia
3300*	1	**Welch Lake aphyric and sparsely pyroxene-phyric massive and pillowed basalt, basaltic andesite and andesite flows**, minor strongly porphyritic flows

*Includes portions of these units exposed in area covered by 1:20 000 scale Preliminary Map 1989S-1.

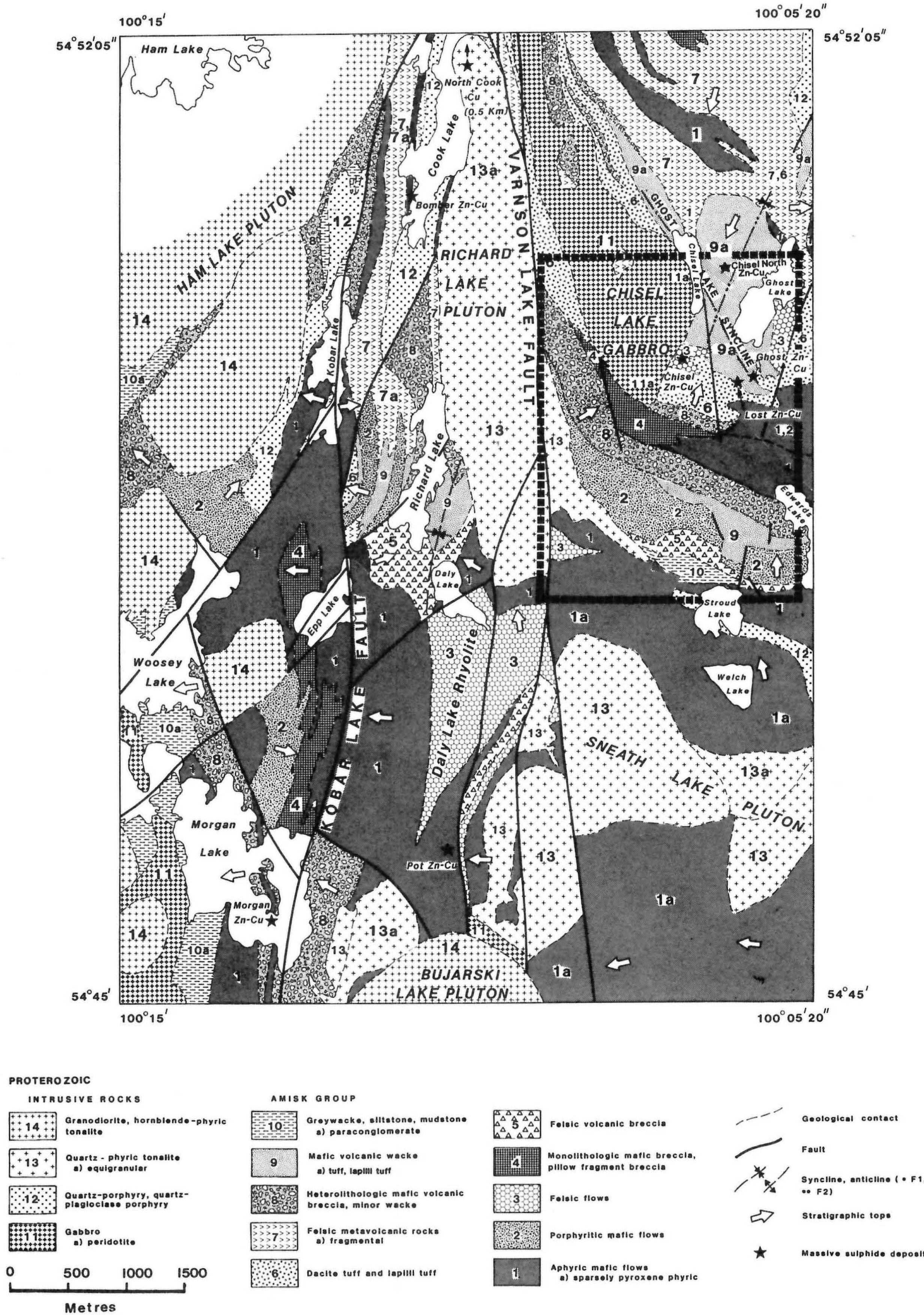

Figure GS-5-1: *Location of Chisel Lake area 1:5 000 scale mapping (bold dashed line).*

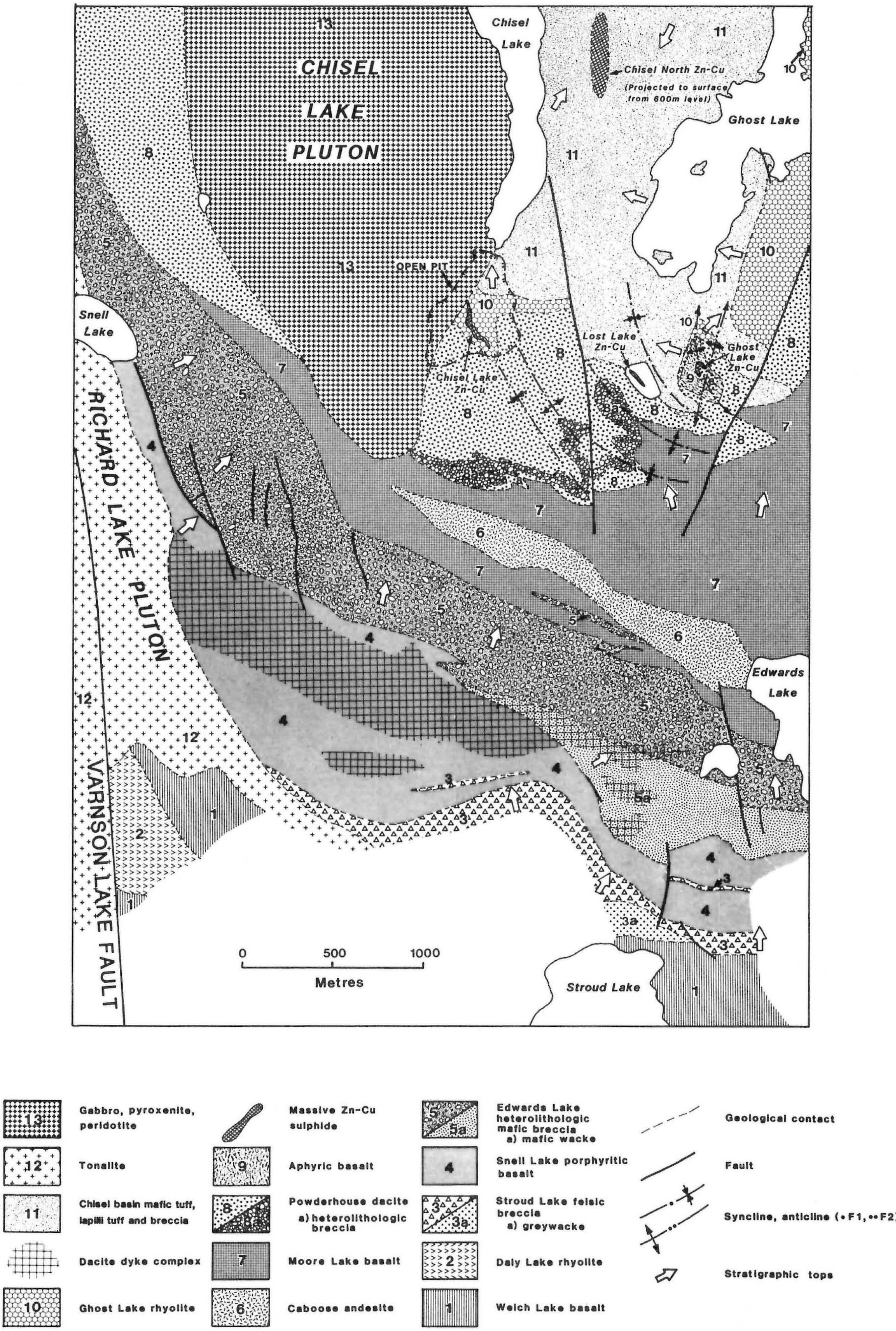

Figure GS-5-2: Simplified geology, Chisel Lake area

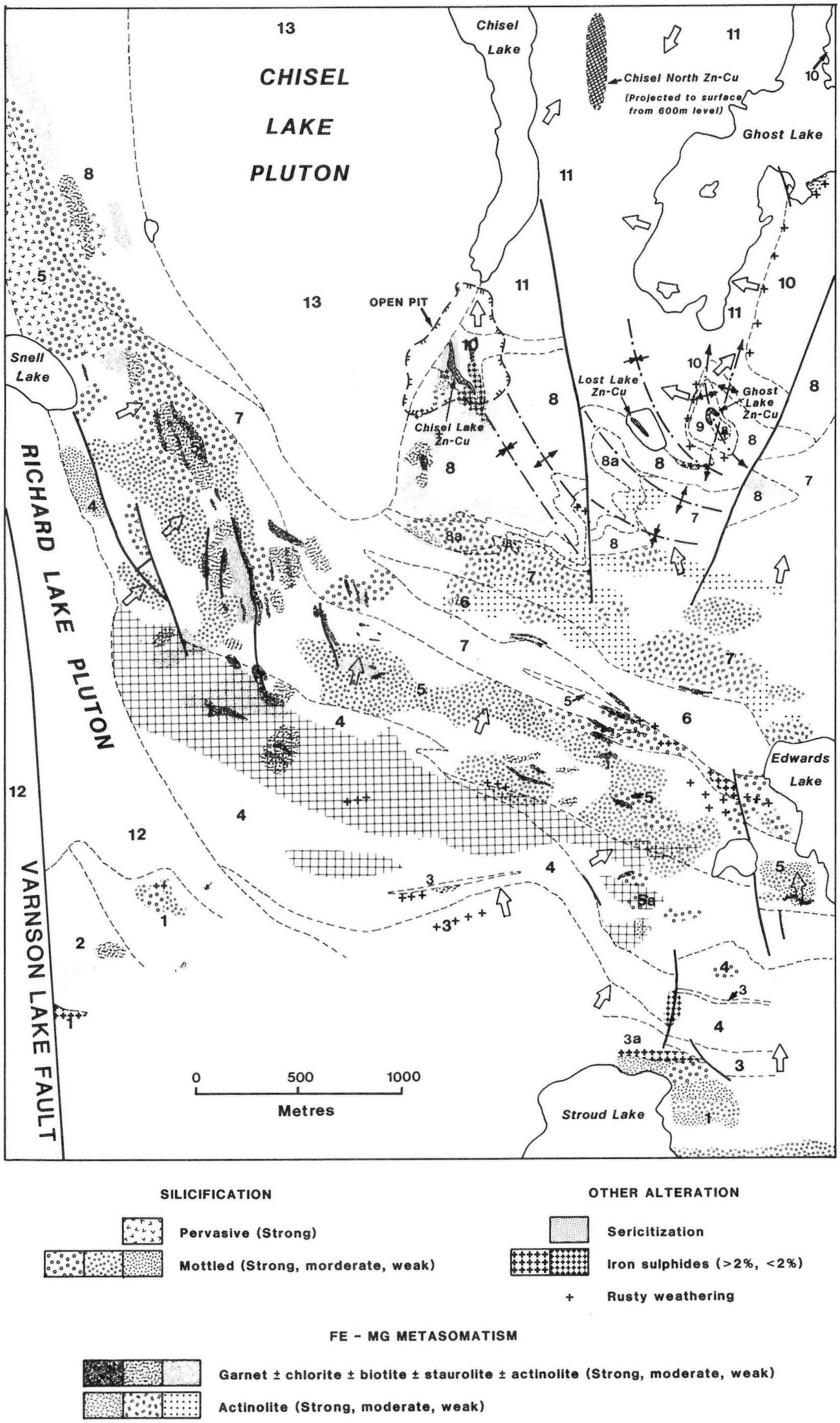

Figure GS-5-3: *Hydrothermally altered rocks, Chisel Lake area.*

The Chisel Lake, Lost Lake and Ghost Lake Zn-Cu massive sulphide deposits occur at or near the same stratigraphic position over a strike length of 1.3km, and are at an equivalent position as the newly discovered Chisel North deposit located 1.6km to the north-northwest (G. Kitzler, pers. com. 1989). They have a number of stratigraphic associations in common with other Flin Flon belt base metal deposits:

1. they occur in a volcanic sequence that displays arc tholeiite affinities (Bailes and Syme, 1989);
2. they are spatially associated with fractionated volcanic rocks (Moore-Powderhouse-Ghost formations, Table GS-5-1) similar to the Cuprus Lake and White Lake base metal deposits of the Flin Flon area (Bailes and Syme, 1989); and,
3. they are at the same stratigraphic position as a major rhyolite complex (Ghost Lake rhyolite), an association they share with almost all significant base metal deposits in Flin Flon belt (Bailes and Syme, 1989), as well as those in many major Precambrian base metal camps (Franklin *et al.*, 1981).

The Chisel Lake, Lost Lake and Ghost Lake deposits have associations in common with other Snow Lake base metal deposits, which are not shared by, or recognized in, other Flin Flon belt deposits:

1. major synvolcanic plutons occur in the vicinity of these deposits (*eg.* Sneath Lake tonalite and Richard Lake tonalite);
2. large semiconformable alteration zones occur 0.5 to 2km stratigraphically below the deposits; and
3. the Chisel Lake, Lost Lake and Ghost Lake deposits are underlain by a volumetrically significant synvolcanic dyke complex (Preliminary Map 1989S-2) that includes dacite dykes with the same fractionated chemical "fingerprint" that characterizes the footwall Moore Lake, Powderhouse and Ghost Lake formations (Bailes, 1988).

HYDROTHERMALLY ALTERED ROCKS STRATIGRAPHICALLY BELOW THE CHISEL DEPOSIT

One of the features that differentiates base metal deposits in the Snow Lake area from those of the Flin Flon area is the much greater volume of hydrothermally altered rocks in their stratigraphic footwall. During 1:5 000 scale mapping of the Chisel Lake area (Preliminary Map 1989S-2) much of the footwall alteration below the Chisel Lake, Lost Lake and Ghost Lake deposits was delineated in order to more fully evaluate the relationship between alteration and base metal mineralization. Samples of least altered rocks and their more altered equivalents have been systematically collected for geochemical analysis to determine elemental gains and losses that occurred during alteration . This information, along with visual estimates of the degree of alteration, will be used to determine the extent and character of element mobilization.

Alteration is recognized at three stratigraphic positions below the Chisel Lake, Lost Lake and Ghost Lake deposits:

a) a discordant zone of alteration immediately below the Chisel Lake deposit,
b) a semiconformable zone 500 to 700m below the deposits in the Moore Lake basalts, and
c) a semiconformable zone, with associated discordant alteration, 1 000 to 2 000m below the deposits hosted by the Edwards Lake formation (Preliminary Map 1989S-2). The discordant zone of alteration directly below the Chisel deposit was examined during 1:1 000 scale mapping of the Chisel mine open pit and is described elsewhere in this volume (Galley and Bailes, 1989).

The two semiconformable zones of alteration display mainly Fe-Mg metasomatism and Si-Ca addition ("silicification"). In the recrystallized rocks of the Chisel Lake area, zones of Fe-Mg metasomatism are characterized by rocks with abnormally high concentrations of garnet, staurolite, chlorite, biotite, actinolite and/or magnetite. Zones of silicification in mafic rocks consist of leucocratic material characterized by high contents of quartz, albite and/or epidote. Weakly to moderately silicified rocks contain garnet, actinolite and magnetite porphyroblasts but this is combined with an increase in quartz and albite, and an overall decrease in amphibole content relative to unaltered material.

The 50 to 300m wide semiconformable zone of alteration, 500m below the Chisel deposit, in the Moore Lake basalt, extends west from the eastern edge of the map area for 2km to the margin of the cross-cutting Chisel Lake Pluton. It consists principally of coarse grained actinolite that increases in grain size and abundance to the west. Western exposures of this zone consist of over 80% coarse actinolite, with 1-2% disseminated pyrite and local small zones of sericite-pyrite schist. Drill holes by HBED into deep parts of the west end of the alteration zone intersected significant volumes of sericite-, kyanite- and staurolite-bearing rocks, with subordinate areas of stringer pyrrhotite-sphalerite- chalcopyrite, similar to the altered rocks found in close proximity to the massive sulphide zone in the Chisel Mine open pit (Galley and Bailes, 1989).

The 500 to 700m wide semiconformable zone of altered rocks 1 000 to 2 000m below the Chisel-Lost-Ghost lakes mineralized horizon extends west and northwest from Edwards Lake to northwest of the project area. Localization of this areally extensive alteration zone within volcaniclastic rocks of the Edwards Lake formation implies that the primary permeability of this 300 to 600m thick unit played a major role in focusing hydrothermal fluid flow and resultant alteration. This is reinforced by the selective occurrence of most strongly altered domains within breccia layers that are interpreted to have had the highest primary permeability (Figs. GS-5-4 and 5). Alteration within this aquifer controlled zone includes large areas of moderately to strongly silicified rocks and equally large domains of Fe-Mg metasomatized material. Although the silicified and Fe-Mg metasomatized domains are locally juxtaposed, it is common for domains of silicification to be selectively developed at the base and Fe-Mg metasomatism to occur at the top of the Edwards Lake formation.

A distinctive feature of the semiconformable alteration zone in the Edwards Lake formation is the presence of several discordant alteration "pipes" 1 km southwest of Snell Lake. These "pipes" consist of areas of strong silicification centered about synvolcanic faults, which themselves contain intense Fe-Mg alteration. The faults and associated alteration cross-cut synvolcanic intrusions and can be followed across stratigraphy for up to 750m (Preliminary Map 1989S-2). The altered faults coincide with an overall increase in level of alteration in the Edwards Lake semiconformable zone and this suggests that they may have focussed the flow of hydrothermal fluids in this formation.

The relationship between the semiconformable alteration zone in the Edwards Lake formation and the one localized in the Moore Lake formation is not known. On surface there is no apparent connection between the two zones and they are compositionally quite different. The actinolite rich Moore Lake zone is more calcium rich and is the only semiconformable zone that contains significant associated sulphides. It is spatially associated with the Chisel Lake deposit and its discordant footwall alteration pipe. The strongest alteration in the Edwards Lake zone is associated with several discordant fault-controlled alteration "pipes" 1km west of the main Chisel orebody. This suggests that there may have been other active seafloor hydrothermal fields besides the one responsible for the Chisel Lake deposit.

SYNVOLCANIC INTRUSIONS

A wide array of mafic to felsic sills, dykes and plugs intrude the Snell Lake basalt and the Edwards Lake heterolithologic mafic wacke/breccia 2 to 3 km stratigraphically below the Chisel Lake, Lost Lake and Ghost Lake Zn-Cu sulphide deposits (Preliminary Map 1989S-2). These intrusions are syn-Amisk as they are intruded by the Amisk- age Richard Lake pluton (Bailes *et al.*, 1988). Most of the intrusions predate deposition of the Chisel Lake, Lost Lake and Ghost Lake massive Zn-Cu sulphide deposits because they are intruded by the dacite dyke complex, interpreted to be a subvolcanic feeder system for the Powderhouse dacite. The subvolcanic character of the dacite dykes is based on identical texture and chemistry of the dykes and the dacite tuff combined with an absence of these dykes in post- Powderhouse units. Consistent with this interpretation is the role these dykes played in promoting hydrothermal alteration. This study and that by Skirrow (1987) clearly demonstrate that the intrusion of dacite dykes has caused mottled silicification of adjacent rocks (Fig. GS-5-6). It is also apparent that the larger scale zones of silicification and Fe- Mg metasomatism are spatially, and probably temporally, associated with this subvolcanic intrusive complex.

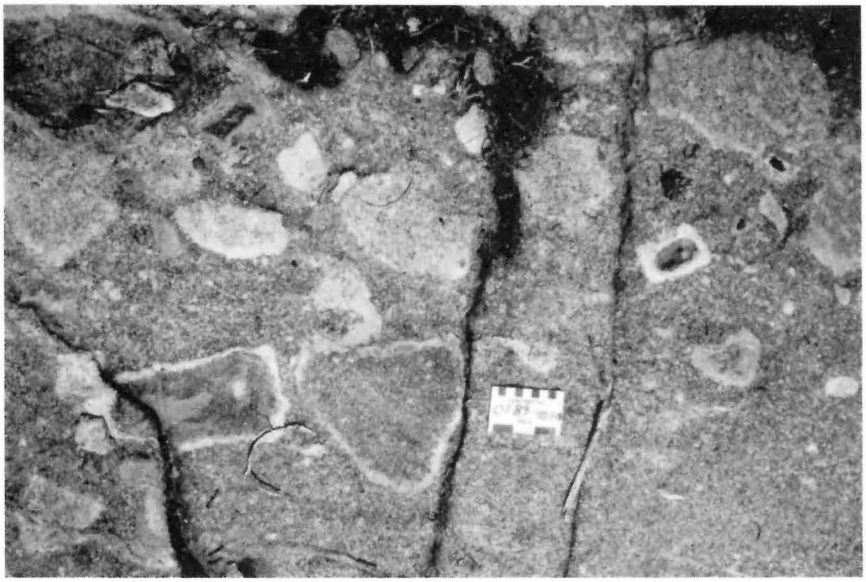

Figure GS-5-4: *Silicified Edwards Lake heterolithologic mafic breccia displaying characteristic partly altered fragments with completely silicified rims and less altered cores.*

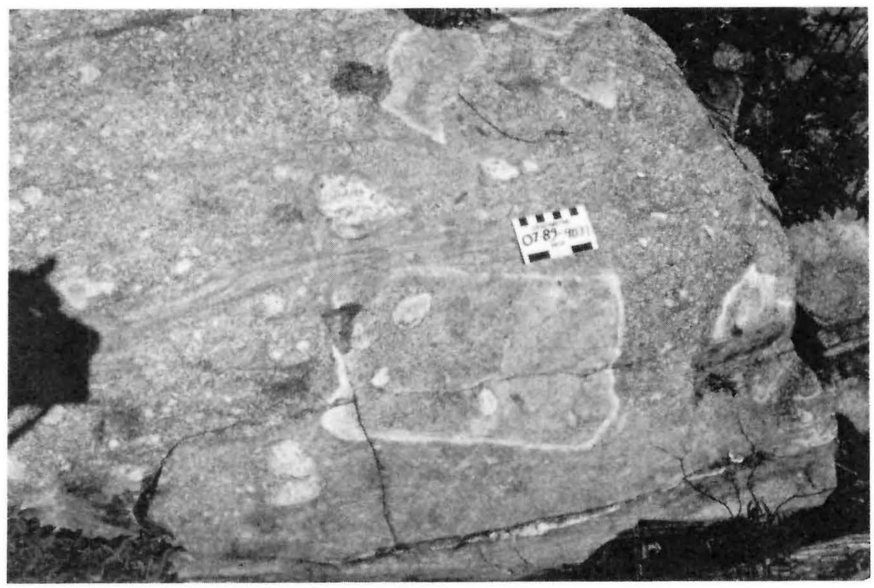

Figure GS-5-5: *Orbicular quartz-plagioclase rich alteration structures in silicified Edwards Lake heterolithologic mafic breccia. Presence of these alteration domains in both fragments and interfragment areas indicates that alteration took place after deposition of the breccia.*

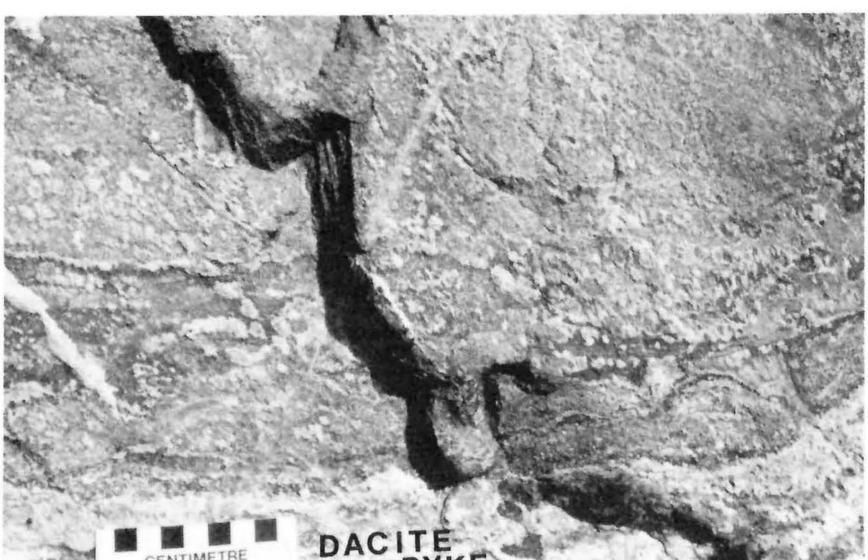

Figure GS-5-6: *Mottled silicification in Edwards Lake mafic wacke adjacent to a dacite dyke. Silicification in the Edwards Lake formation is spatially associated with dacite dykes at both outcrop (this example) and regional scale.*

At this stage in the project it is not possible to properly evaluate the relative importance of the subvolcanic dyke complex and the large synvolcanic Sneath Lake and Richard Lake tonalite plutons to generation of the geothermal-hydrothermal system and related base metal mineralization. One possibility is that the large tonalite plutons were responsible for elevating the overall geothermal gradient, with hydrothermal activity further focussed by the dyke complex.

ACKNOWLEDGMENTS

We thank the staff of Hudson Bay Mining and Smelting and Hudson Bay Exploration and Development for their continued support for our mapping program in the Chisel Lake area. Access to detailed company maps and to diamond drill data has greatly assisted us in developing and implementing this project. We appreciate willingness of staff geologists to share with us their knowledge and ideas about geology of the area.

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GS-6 ATHAPAPUSKOW LAKE PROJECT: STATUS REPORT

by E.C. Syme

Syme, E.C. 1989: Athapapuskow Lake project: status report; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The Athapapuskow Lake project entails detailed, 1:15 840 mapping of Early Proterozoic metavolcanic, metasedimentary and intrusive rocks in the southwestern portion of the Flin Flon metavolcanic belt. Field work in 1988 completed a three year study of the area (Fig. GS-6-1); in 1989 two weeks were spent mapping in selected areas, sampling for whole-rock geochemistry and sampling for U/Pb zircon geochronology. The additional information collected does not significantly alter previous interpretations nor 1988 preliminary maps.

PRODUCTS

During the course of the Athapapuskow Lake project four Preliminary Reports were produced (Syme, 1985, 1986, 1987, 1988) that describe the geology of the area in some detail. For the Amisk Group, the lithologic and geochemical characteristics of all major units are summarized. The stratigraphic sequence in a fault-bounded panel of Missi Group rocks is described, and all plutons are detailed according to composition and internal zoning. The complex structural geology of the area, dominated by tight folding of the supracrustal rocks and a system of late, north- to northeast-trending faults and shear zones, is described in each Preliminary Report. The mineral potential of the area is reviewed in the 1987 and 1988 reports.

A total of seven 1:15 840 scale preliminary maps were produced, with substantial revisions incorporated into the latest versions issued in 1988. Further revisions in both interpretation and legend are expected before the final coloured version of the map is published at 1:20 000 scale.

A geochemical database comprising 185 whole-rock chemical analyses of igneous rocks (including Amisk Group metavolcanic rocks, granitoid plutons and layered gabbroic complexes) has been entered in a LOTUS spreadsheet to facilitate computer manipulation of the data. All of the analyses contain precise major-element determinations, and most also include comprehensive trace and rare earth element packages. Some of the results have been discussed in the 1988 Preliminary Report, as well as in an outside publication (Syme, in press). The entire data set will be published in the final geological report.

Microprobe analyses of relict pyroxene phenocrysts in Amisk Group mafic volcanic rocks were carried out at the University of Manitoba (Turnock and Syme, 1988); this ancillary project resulted from the recognition of subgreenschist facies rocks during this project and a previous project in the Flin Flon-White Lake area (Bailes and Syme, 1989). The results of this research, which confirm interpretations made from the whole-rock geochemistry that the Amisk Group contains island-arc type lavas, are currently being prepared (Turnock and Syme, in prep.).

U/Pb zircon geochronologic studies in the Flin Flon area during the MDA resulted in the first precise date for the Amisk Group (Syme *et al.*, 1987). Results of this program have subsequently been published in comprehensive papers dealing with the geochronology of the southern Churchill Province (Gordon *et al.*, 1987; Gordon *et al.*, in press).

A number of formal and informal field trips were conducted through both the Flin Flon-White Lake and Athapapuskow Lake areas during the MDA. A field trip guide book was published to accompany one of these (Bailes *et al.*, 1987).

Current work on the Athapapuskow project has involved computerization of the outcrop data, by back-entry into a DBASE system developed by P. Lenton of Geological Services Branch. Computerization has resulted in the ability to search the field database for any specified lithologic or structural feature, to organize information on specific units very rapidly, and to extract and export data to other systems such as word processing or structural analysis programs. Ultimately computerization will result in a substantial decrease in the time required to analyze voluminous field data during production of reports, resulting in more rapid report production. The longer term target for geological field databases is to produce an archival system accessible by the public. This will enable the mining industry to obtain detailed geological information at the outcrop level.

With the field component of the Athapapuskow project completed, work is now focused on producing a final report and coloured geological maps at 1:20 000 scale.

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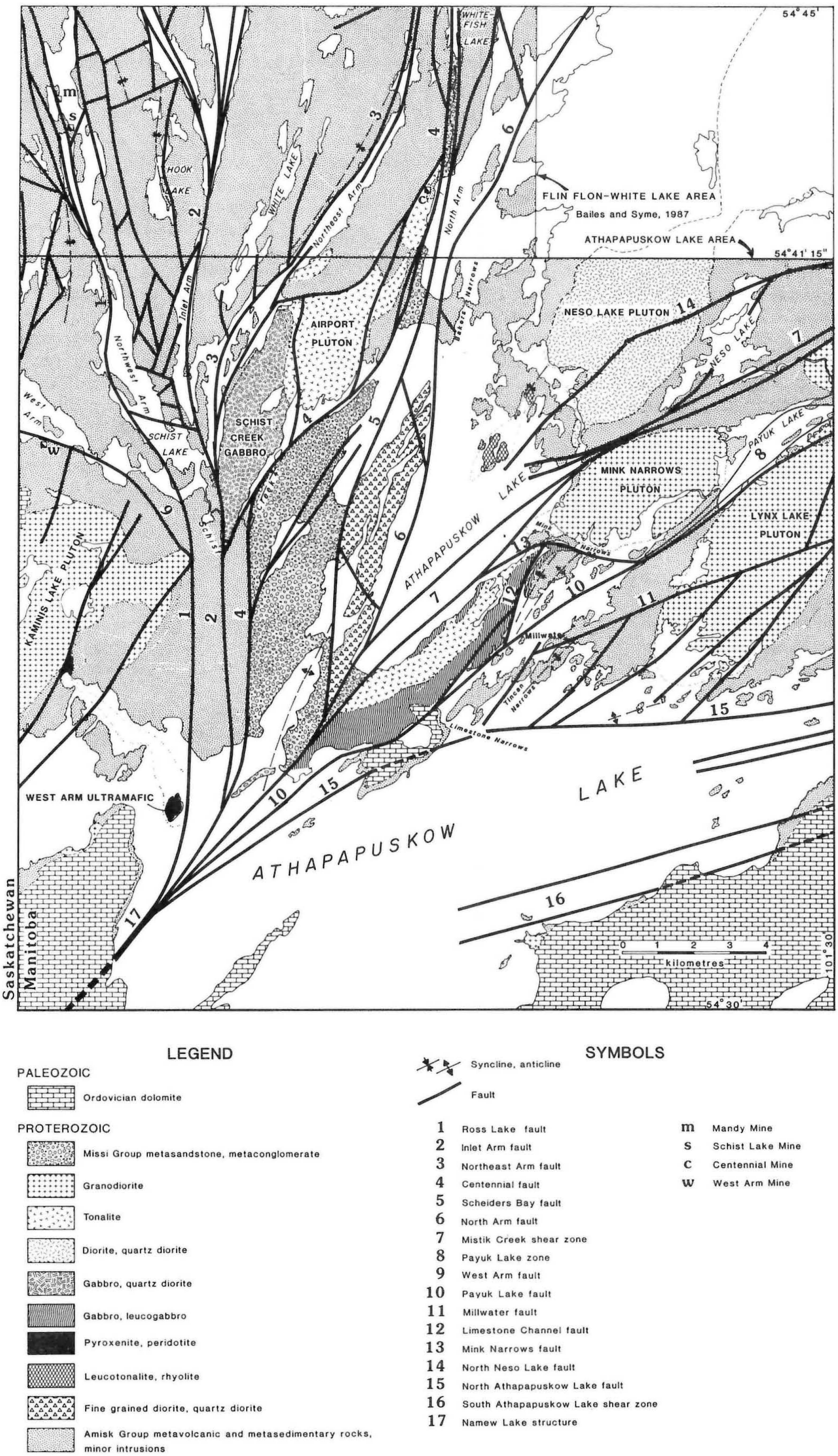

Figure GS-6-1: *Athapapuskow Lake project area with simplified geology.*

GS-7 GEOLOGICAL INVESTIGATIONS IN THE KISSISSING LAKE AREA

by H.V. Zwanzig and D.C.P. Schledewitz

Zwanzig, H.V. and Schledewitz, D.C.P. 1989: Geological investigations in the Kississing Lake area; **in** Manitoba Energy and Mines, Minerals Division, 1989.

Mapping of the Kississing-Batty-Limestone Point lakes area was carried out between 1983 and 1988 on 1:15 840 scale airphotographs and compiled at 1:50 000 scale on Preliminary Maps 1988K-1 and 1988K-2. More detail is shown at 1:20 000 scale in the western half of the project area on Preliminary Maps 1984K-1, 1987K-1 and -2, and in parts of the eastern half of the project area on Preliminary Maps 1984K-2 and -3, and 1987K-4. Lithostratigraphic and structural frameworks for the area with field descriptions of the main rock types have been provided in preliminary reports (Schledewitz, 1985, 1987 and 1988; Schledewitz and Trembath, 1986; Zwanzig, 1983, 1984, 1985, 1988; Zwanzig and Lenton, 1987). A coloured preliminary compilation map of NTS area 63N was prepared at 1:250 000 scale, in part, using data of the Kisseynew project (Manitoba Energy and Mines, 1988).

Analysis of the Kisseynew project field data has included creating a complete electronic data base for structural readings and partial back-entry of lithologic codes into a DBASE system developed by P.G. Lenton. At present, computer plotted equal area stereograms of all subfabrics have been generated from the data base for structural subdomains of the project area.

Two papers concerning aspects of the Kisseynew project are ready for publication: "Pre-Missi granitoid domes in the Puffy Lake area, Kisseynew gneiss belt, Manitoba" (Hunt and Zwanzig, 1989) and "The Kisseynew gneiss belt in Manitoba: stratigraphy, structure and tectonic evolution" (Zwanzig, in prep.).

Revised 1:50 000 scale compilation maps of the Kisseynew project area and an Open File Report are also in preparation. The final product will be full colour 1:50 000 scale maps, selected black-line 1:20 000 scale maps and a Geological Report.

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GS-8 TILL GEOCHEMISTRY OF THE KISSISSING LAKE AREA, MANITOBA

by G. Gobert and E. Nielsen

Gobert, G. and Nielsen, E. 1989: Till geochemistry of the Kississing Lake area, Manitoba; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

Regional overburden sampling in the Kississing Lake area, (NTS 63N/3), was conducted to map till geochemical anomalies and to establish local and regional background values of till geochemistry within the Kisseynew gneissic domain. The Kississing Lake area has a high mineral potential due to the wide areal extent of lithologies associated with mineralization. Thus, it is an ideal setting for documentation of regional till geochemistry.

Access to the south and southeastern portions of the lake is possible by road, with subsequent access to the entire lake by boat. One sample per km^2 was initially chosen as the target sample density for the project. Practical limitations associated with clay cover and bedrock resulted in a realized density of approximately 6.4 km^2 per sample (Fig. GS-8-1). A total of 171 samples (148 till, 23 littoral), averaging 7 kg each were taken from 139 hand dug pits varying between 0.25 m and 1.2 m in depth. Detailed profile sampling was conducted at 8 locations with 40 samples being taken to "evaluate geochemical variability resulting from surface weathering and primary sedimentological factors" (Kaszycki, 1989, p. 1).

PREVIOUS WORK

Till sampling within the map sheet was undertaken by Kaszycki in 1986. Sampling consisted of 92 samples from 56 locations, and a multi-sample copper-arsenic-gold anomaly was mapped south of Kississing Lake (Kaszycki, 1989).

In a follow-up study, resulting from this discovery, Nielsen and Gobert (1988) collected 50 samples in the southwest portion of the map sheet. Visible gold (59 grains total) was identified in 26 samples. The abraded nature of the majority of the grains indicated they had undergone extended glacial transport (Nielsen and Gobert, 1988).

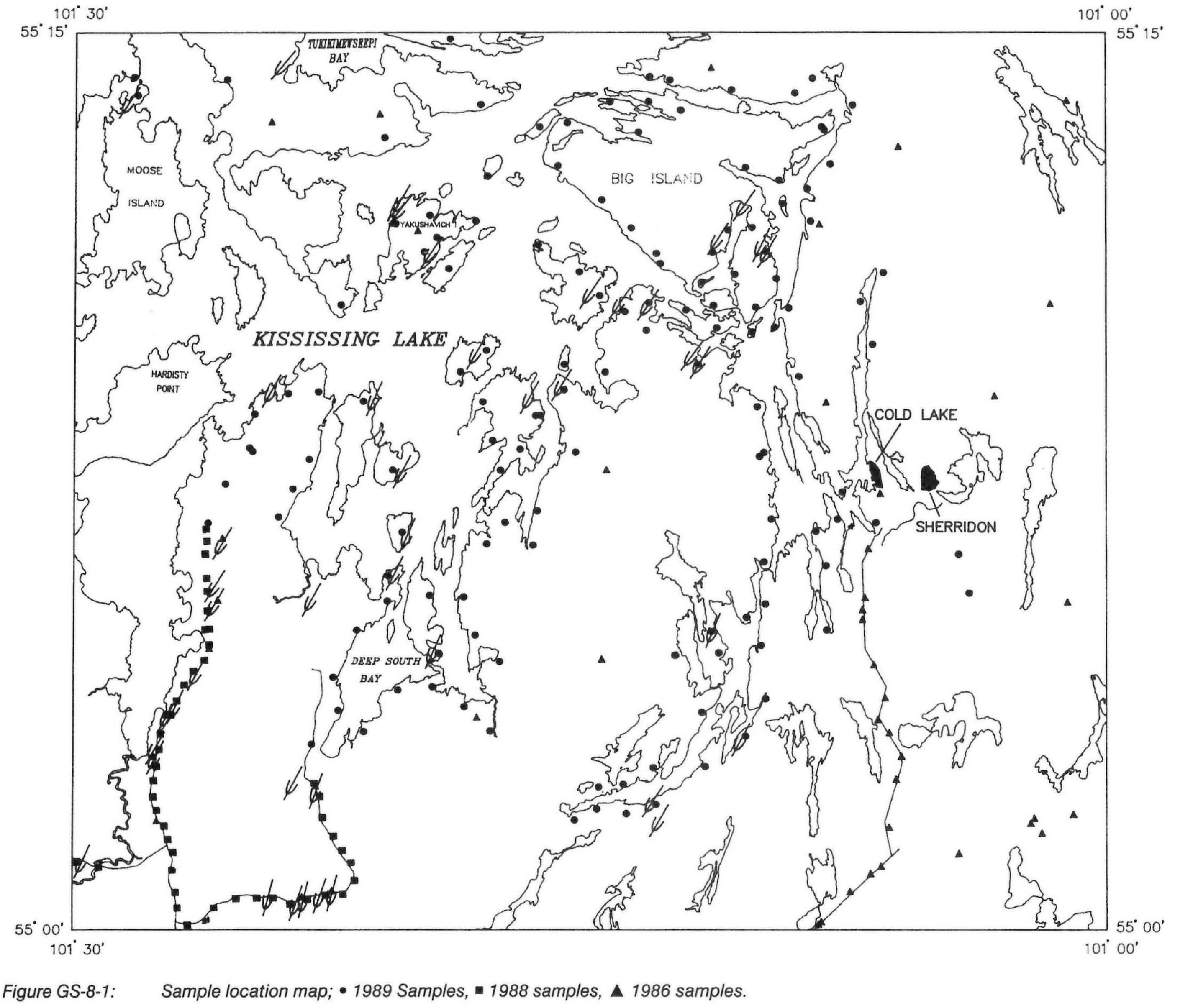

Figure GS-8-1: Sample location map; • 1989 Samples, ■ 1988 samples, ▲ 1986 samples.

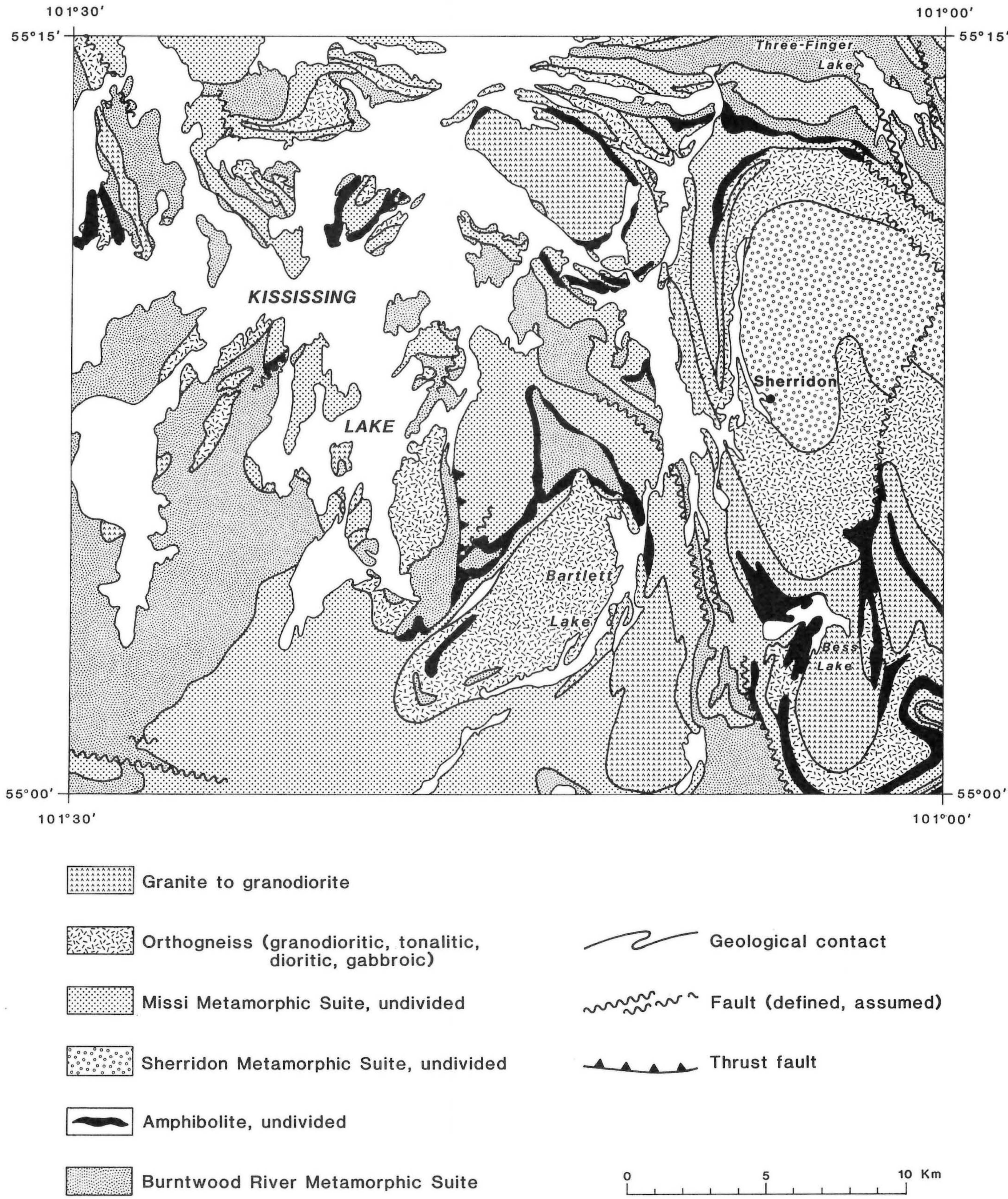

Figure GS-8-2: Simplified geology of the Kississing Lake map area (after Schledewitz, 1988a).

BEDROCK GEOLOGY

The bedrock geology has been described by Schledewitz (1987, 1988a). The Kississing Lake area exhibits 4 mappable components of the Kisseynew gneisses; the Burntwood Metamorphic Suite, a suite of amphibolites and associated rocks, the Sherridon Metamorphic Suite, and the Missi Metamorphic Suite. Two groups of igneous rocks; a collection of orthogneisses, and a granitic to granodioritic assemblage occur in the area (Fig. GS-8-2).

Economic attention has been focused on massive sulphide mineralization within the Sherridon Suite. Sulphide mineralization is also associated with the amphibolite assemblage, specifically units 3a-3c-3g as mapped by Schledewitz (1988b), at several localities around the lake.

SURFICIAL GEOLOGY

Elevations within the map sheet range between 313 m (Kississing Lake level) and 343 m A.S.L. Significant bedrock exposures occur on west-central Big Island, Yakushavich Island, eastern regions of South Bay area, and the Adamson and Bartlett Lake areas.

Striations within the area record ice flow between 202° and 220°, with regional ice flow averaging 210° (Fig. GS-8-3). The till is generally thin (0-2 m) and may be covered by extensive clay in low lying areas, (below 328 m), or by nearshore glaciolacustrine deposits flanking bedrock ridges. A large south-southwest trending esker occupies essentially all of Hardisty Point, and extends northward through Moose Island to the western end of Tukikumewseepi Bay (Kaszycki and Way-nee, 1989).

GEOCHEMICAL ANALYSIS

The silt plus clay (less than 63 micron) fraction will be analysed by neutron activation, using a Au plus 33 package on the 171 samples collected in 1989, the 50 collected in 1988, and on 80 collected in 1986. The less than 2 micron fraction from these samples, will be analysed by atomic absorption for copper, lead, zinc, nickel, cobalt, chrome, iron, and manganese. Arsenic in the less than 2 micron fraction will be analysed colorimetrically.

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Figure GS-8-3: Striae on NE Big Island.

GS-9 PRELIMINARY OBSERVATIONS ON THE METALLOGENY OF THE HERBLET LAKE AND PULVER LAKE GNEISS DOME COMPLEXES, SNOW LAKE AREA

by M.A.F. Fedikow, C. Malis[1] and A. Lebedynski[1]

Fedikow, M.A.F., Malis, C., and Lebedynski, A. 1989: Preliminary observations on the metallogeny of the Herblet Lake and Pulver Lake Gneiss Dome Complexes, Snow Lake area; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

Documentation of mineralization and associated alteration zones in the Snow Lake area, including the Herblet and Pulver Lake Gneiss Dome Complexes, has been ongoing since 1984. This documentation has produced an abundance of information on the geological and geochemical characteristics of the mineral occurrences.

This report describes detailed investigations undertaken in the vicinity of some of the occurrences hosted by the light grey to salmon pink granitoid gneisses and amphibolite gneisses that characterize the Herblet Lake and Pulver Lake Gneiss Dome Complexes (Bailes, 1975). A preliminary statement regarding the metallogenetic implications for the gneiss domes is developed on the basis of these examinations. Unit descriptions and designations originally proposed by Bailes (1975) in his geological report of the Guay-Wimapedi area are utilized in this report. Figure GS-9-1 gives the general geology of the areas investigated and the location of occurrences discussed in the text.

I. Dowling Lake

A garnet-anthophyllite-chalcopyrite ± pyrite occurrence described by Fedikow and Malis (1988) was examined in more detail this year. Occurrence 10 (Fig. GS-9-1) is exposed on the east and west shores at the back of a bay along the northwest shore of Dowling Lake. Outcrop stripping and examination of the host melanocratic hornblende-plagioclase gneiss indicates the garnet-anthophyllite-chalcopyrite zone persists for a minimum of 1 km in an east-west direction. Figures GS-9-2, 3 and 4 present the geological characteristics of this zone at occurrence 10. Mineralogically, this zone contains 3-100%, 4-5 cm^2 radiating clusters of anthophyllite, red garnets with 5-6 cm diameters and 1-5% chalcopyrite. This alteration is primarily developed within the hornblende-plagioclase gneiss. A single outcrop located in swampy ground to the north of this zone (Fig. GS-9-2) is strongly silicified and consists predominantly of medium grained quartz with minor garnet and black biotite. The garnet porphyroblasts in the garnet-anthophyllite zones are commonly rimmed by, or have cores of, chalcopyrite and very minor pyrite. In some outcrops the amphibolite has been silicified to produce a discordant silica-garnet zone. At other locations along the zone radiating sheaves of anthophyllite in rusty weathered amphibolite define a tight fold that redirects the amphibolite and contained alteration northward where outcrop disappears beneath swamp. Two rock geochemical samples collected from occurrence 10 in 1988 contained a maximum of 0.5% Cu.

Similar alteration has been mapped at two additional localities (Fig. GS-9-1) along the hornblende-plagioclase gneiss mapped as C1 by Bailes (1975). The alteration zone at occurrence 18 (Fig. GS-9- 5) occurs at the edge of an outcrop along a linear east-west swamp between pink C3 granitoid gneiss and white to grey C1 granitoid gneiss. The zone is characterized by a coarse grained rusty weathered garnet-anthophyllite-black biotite-quartz-feldspar mineral assemblage developed within amphibolite gneiss. Sulphide mineralization within this alteration zone is restricted to rare grains of pyrite. At occurrence 19 (Fig. GS-9-6) an apparent 1-3 m wide zone of garnet-cordierite-biotite-anthophyllite-quartz-feldspar alteration is developed within locally rusty weathered amphibolite gneiss. Garnet and cordierite porphyroblasts attain maximum diameters of 3 cm. Dimensions of this zone are difficult to ascertain owing to lichen-covered outcrop. Approximately 25 m south of this alteration is a 1 m^2 zone of rusty weathered amphibolite containing 1% pyrite and distorted quartz veins, pods and lenses. The eastward extent of this zone is obscured by swamp.

There are few clues available to indicate the genesis of the alteration zone as represented by occurrences 10, 18 and 19. The zone is primarily confined to the amphibole-plagioclase gneiss (unit C2,; Bailes, 1975), and is relatively sulphide poor except for 1-5% chalcopyrite at occurrence 10. The zone is not sheared although the strongly silicified outcrop located in a linear east-west trending swamp north of occurrence 10 (Fig. GS-9-2) is suggestive of focussed fluid flow producing silicification in an amphibolite(?) gneiss. If the linear swamp and the silicified outcrop represent a fault or shear zone then the alteration zone at occurrence 10 could represent a subsidiary *en echelon* shear zone, with the structural fabric obscured by metamorphic recrystallization of altered primary mineralogies. The structural disruption and accompanying alteration would predate peak metamorphism and the latest folding event since the alteration zone is redirected northwards within a folded rusty-weathered amphibolite. The shearing event in the amphibolite gneiss may be related to the different rheologic characteristics of the sequence at Dowling Lake. The relatively thin amphibolite gneiss at Occurrence 10 is flanked to the north and south by a thick sequence of felsic granitoid gneisses. The amphibolite would represent the strain focus and a natural site for focussed fluid flow and alteration. The 0.5% Cu at occurrence 10 may have been derived from previously deposited mineralization subsequently mobilized to the present location.

An alternative hypothesis is related to the presence of a proposed rhyolite (Bailes, 1975) centered on Dowling Lake and the interlayering of the amphibolite with these felsic gneisses. If the felsic gneisses represent rhyolitic extrusive or volcaniclastic rocks then the interlayered mineralized and altered amphibolite gneiss may represent clastic and/or chemical sedimentary rocks deposited in the volcanic pile during volcanic quiescence. Accordingly, occurrence 10 may represent the fringes of a more extensive altered and mineralized zone at depth. The presence of garnet-cordierite gneiss at occurrence 19, developed within amphibolite gneiss, represents additional evidence of significant elemental gains and losses accompanying focussed fluid flow within the amphibolite gneiss.

II. Chartier Lake

In the southeast portion of Chartier Lake an alteration zone developed within C2 amphibolite gneiss was described by Fedikow and Malis (1988). This alteration zone (occurrence 26) and the peninsula to the northwest (occurrence 29) were mapped in detail to elucidate the alteration systems present at these two localities (Fig. GS-9-1). Both occurrences are described together due to their geological similarities.

Figures GS-9-7 and GS-9-8 are outcrop, geology and geochemical sample location maps for occurrences 26 and 29, respectively. Both alteration zones are developed in amphibole-plagioclase gneiss mapped as C2 by Bailes (1975). The amphibolite at these locations is rusty weathered due to the oxidation of up to 5% disseminated pyrite, pyrrhotite and chalcopyrite. Occurrence 26, the narrow strip of land between Chartier Lake and Sheps Lake, is characterized by silicified, garnetiferous amphibolite. The melanocratic amphibole-plagioclase bands are interlayered with bands of quartz-feldspar-garnet ± magnetite and biotite that may represent felsic interbeds within the amphibolite gneiss or silicified amphibolite. The same geological setting is apparent for occurrence 29 (Fig. GS-9-8) where outcrop stripping indicates the eastern half of the peninsula consists of white to beige garnetiferous quartzofeldspathic layers containing very faint bands or zones of amphibole. These felsic layers can be rusty weathered and contain 1-2% disseminated pyrite. Zones of altered (rusty weathered and garnetiferous) and unaltered amphibolite occur within the quartzofeldspathic unit. The unaltered amphibolite has a sharp, planar contact with the quartzofeldspathic unit and may be a dyke, although insufficient outcrop is available to ascertain the genesis of this unit. Altered amphibolite commonly has an undulose and indistinct contact with the quartzofeldspathic rocks and accordingly the quartzofeldspathic zones may represent silicified amphibolite. Two small islands south of the peninsula were mapped as C2 amphibolite

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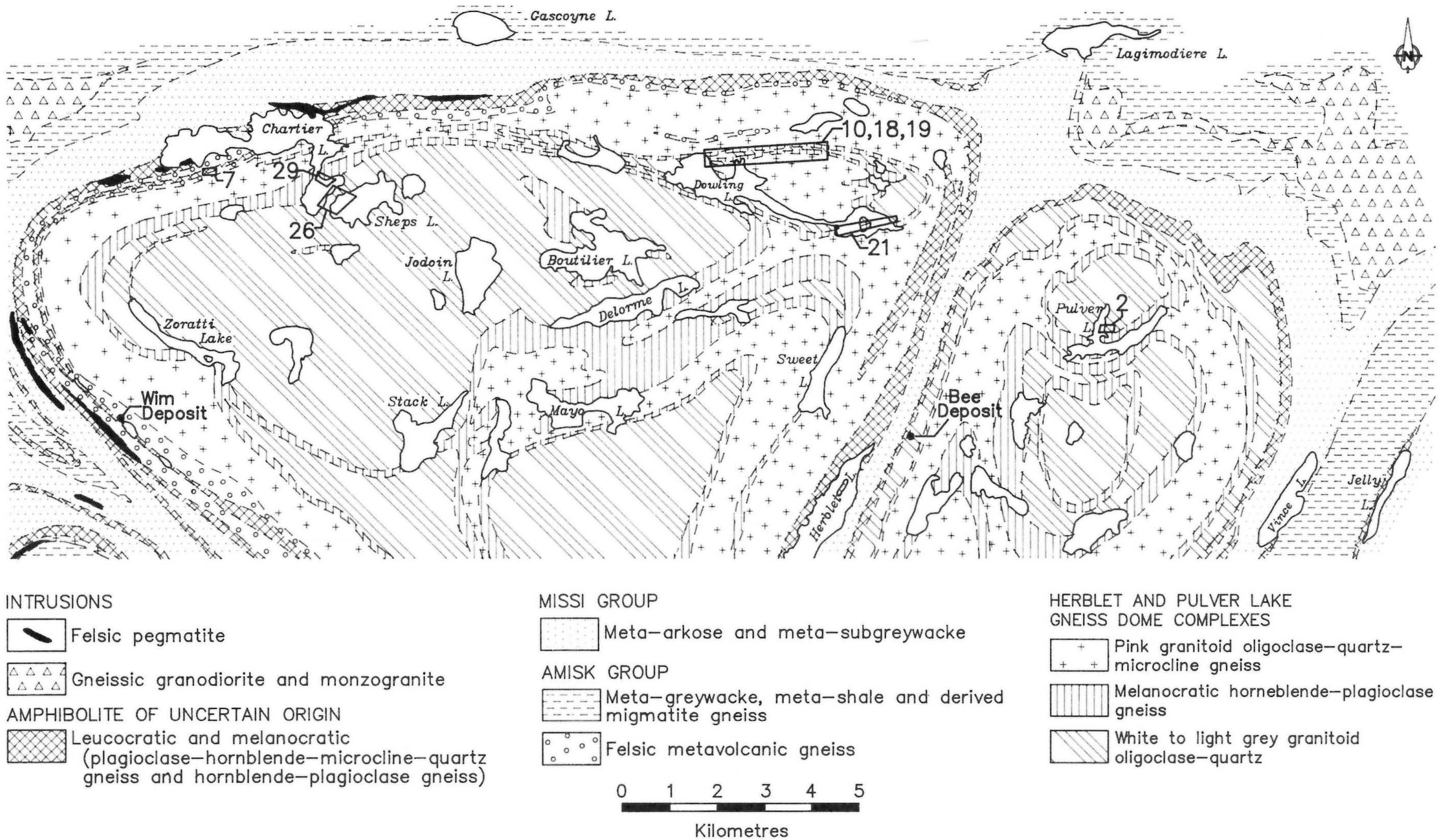

Figure GS-9-1: *Location map of the study areas in the Herblet Lake and Pulver Lake Gneiss Dome Complexes (geology modified from Bailes, 1975).*

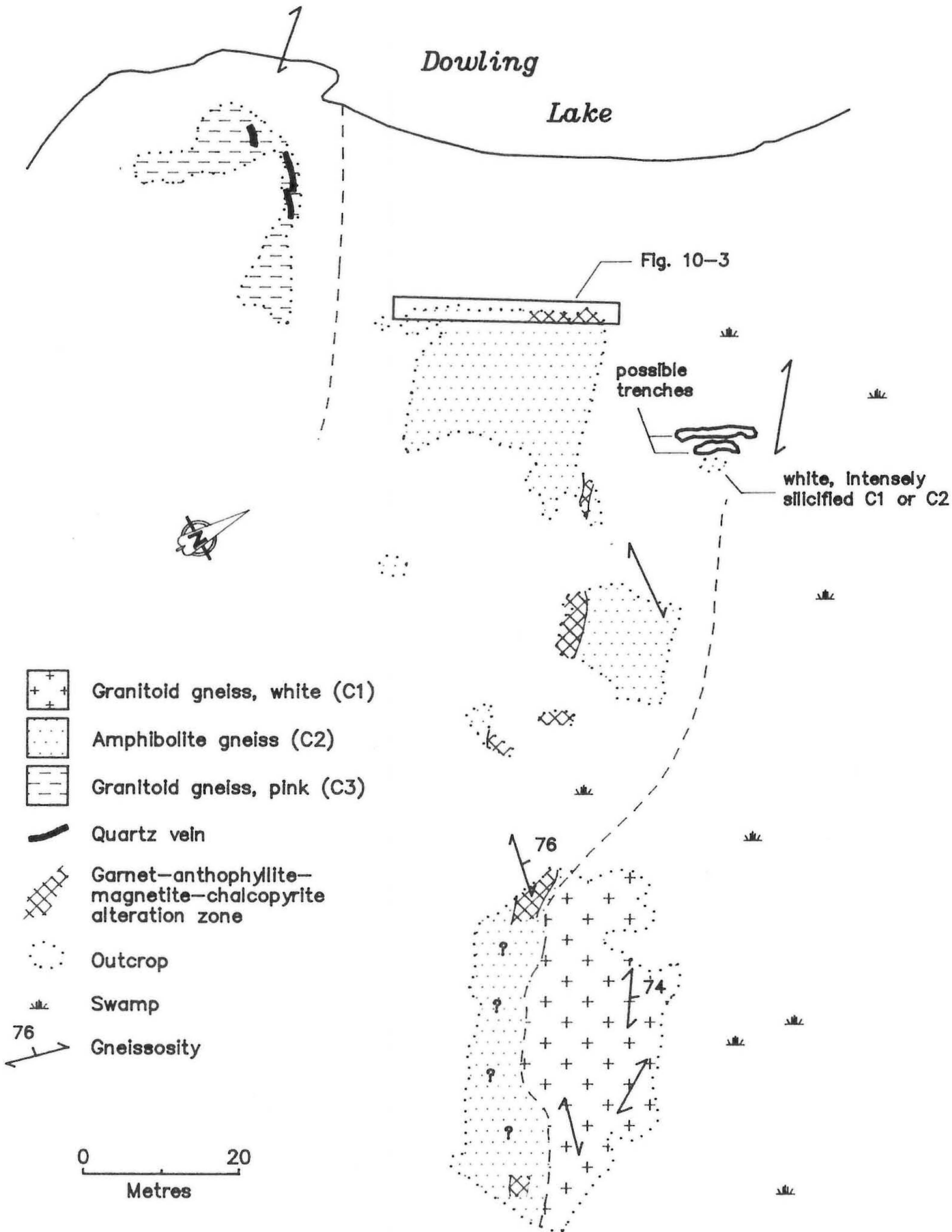

Figure GS-9-2: Outcrop and geology map, occurrence 10 (63O/4).

gneiss (Bailes, 1975), however, these islands are characterized by rocks with a quartz-feldspar-garnet-biotite +/- amphibole mineralogy. A further complication for the understanding of occurrences 26 and 29 is the observation that the mineralogy of the quartzofeldspathic rocks at these localities is similar if not identical to the quartzofeldspathic rocks mapped by Bailes (1975) as felsic metavolcanic gneiss or rhyolite. The felsic metavolcanic gneiss, exposed on the northeast shore of Chartier Lake, is also interlayered with an amphibolite gneiss.

Occurrences 26 and 29 are characterized by 1-5% disseminated pyrite, pyrrhotite and chalcopyrite in association with silicified and garnetiferous amphibolite. The nature of the quartzofeldspathic rocks at these two locations is enigmatic due to the lichen-covered nature of the outcrop. Although poorly exposed outcrop obscures the exact nature of the mineralized zones the iron and copper sulphide minerals appear to be related to diffuse zones of silicification with northeast trends, parallel to gneissosity.

A second zone of intense but areally limited mineralization and alteration is located at occurrence 7 (63N/1, Fig.GS-9-9). The occurrence is hosted by amphibolite gneiss mapped as unit 6a by Bailes (1975). The amphibolite consists of laterally continuous 0.5-1.0 m thick bands of quartz-feldspar +/- magnetite interlayered with amphibolite-plagioclase-quartz-rich beds. The quartzofeldspathic bands can be rusty weathered but visible sulphide minerals are absent. Both felsic and mafic bands are cross-cut by white pegmatite dykes and white quartz veins without visible sulphide minerals. In proximity to these later intrusions the amphibolite has been altered to a mineralogy of 80-90% red garnet with 5-6 cm diameters and 10-20% black biotite, quartz and feldspar. These garnetite zones appear as 10 cm wide linear zones or as 1-2 m^2 lenses. Away from these zones 1-3 mm garnets are present in the amphibolite. Sulphide mineralization consists of 1-5% disseminated pyrrhotite in rusty weathered, silicified amphibolite. This occurrence is flanked to the north by garnetiferous rhyolite (unit 1; Bailes, 1975) marked by rusty weathered zones containing 1% pyrite, and to the south by relatively unaltered pink C3 granitoid gneiss.

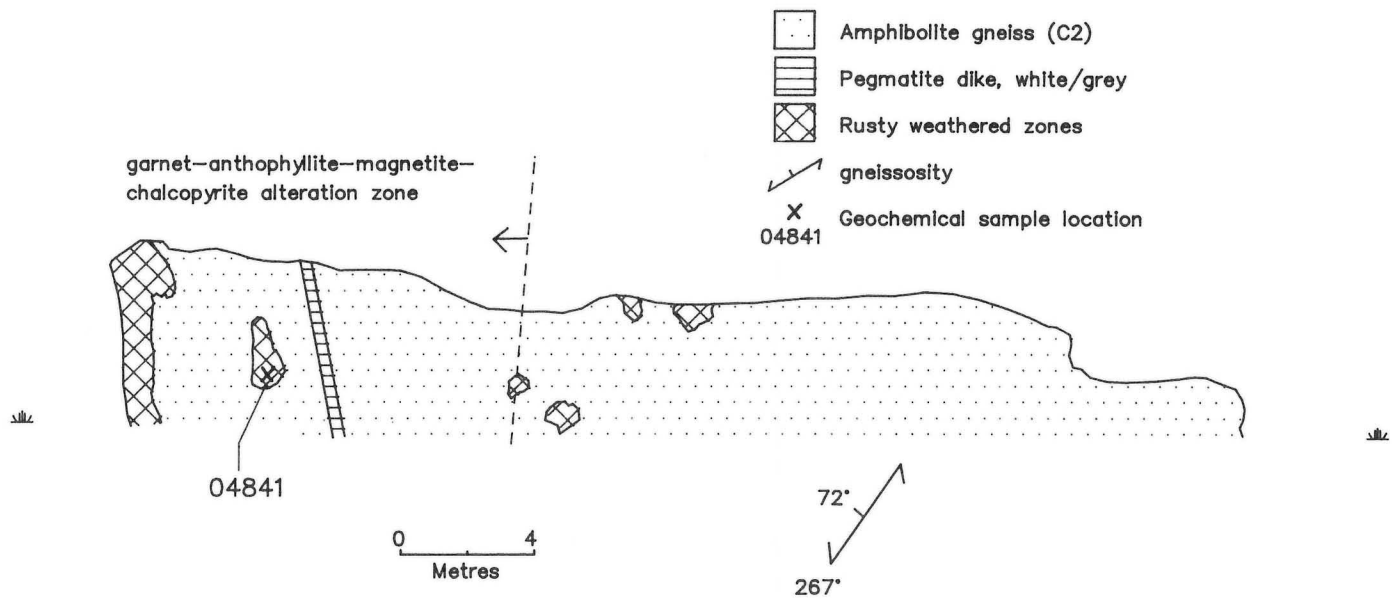

Figure GS-9-3: Section looking east through occurrence 10 (63O/4).

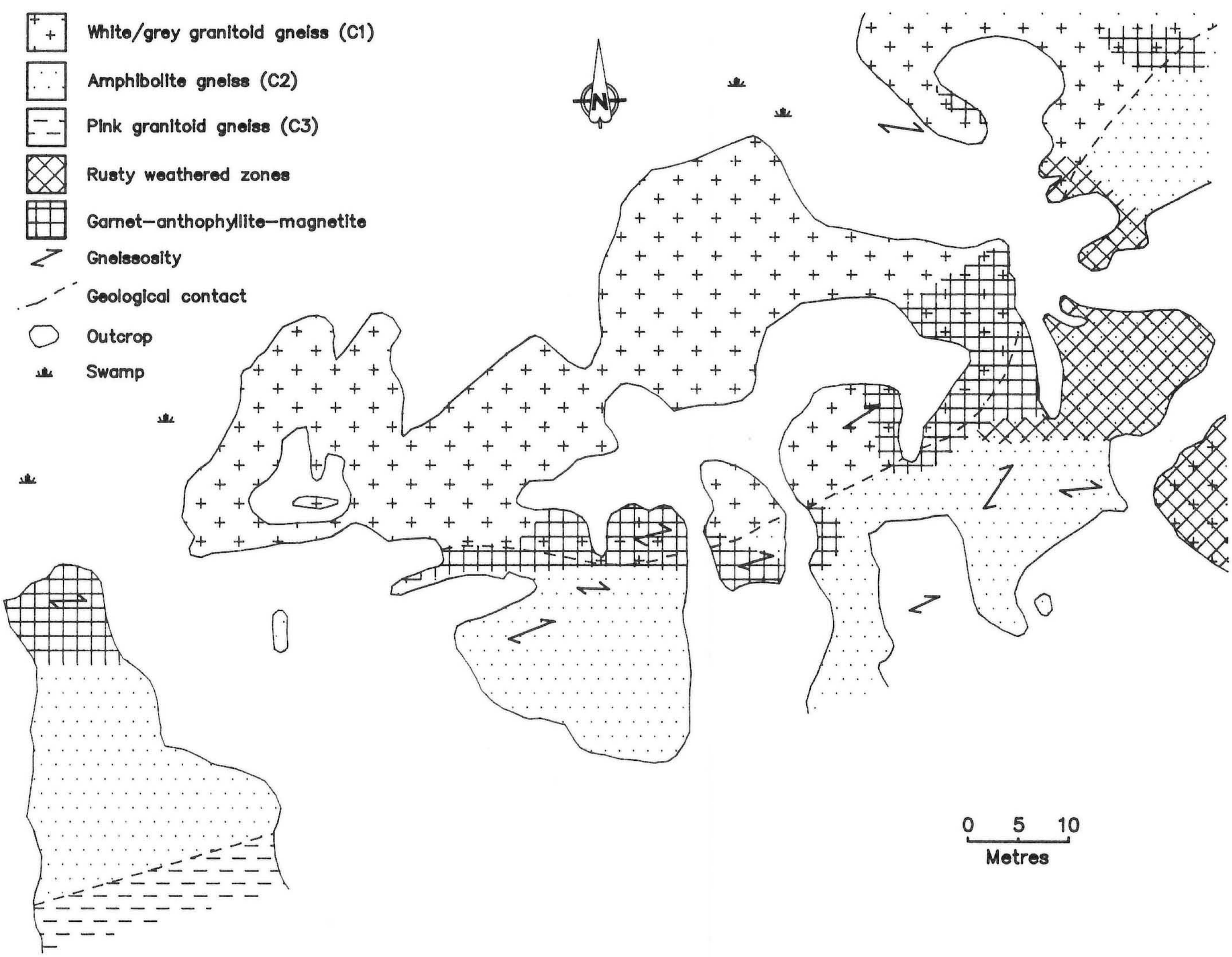

Figure GS-9-4: Geology and distribution of alteration types, eastern portion of occurrence 10 (63O/4).

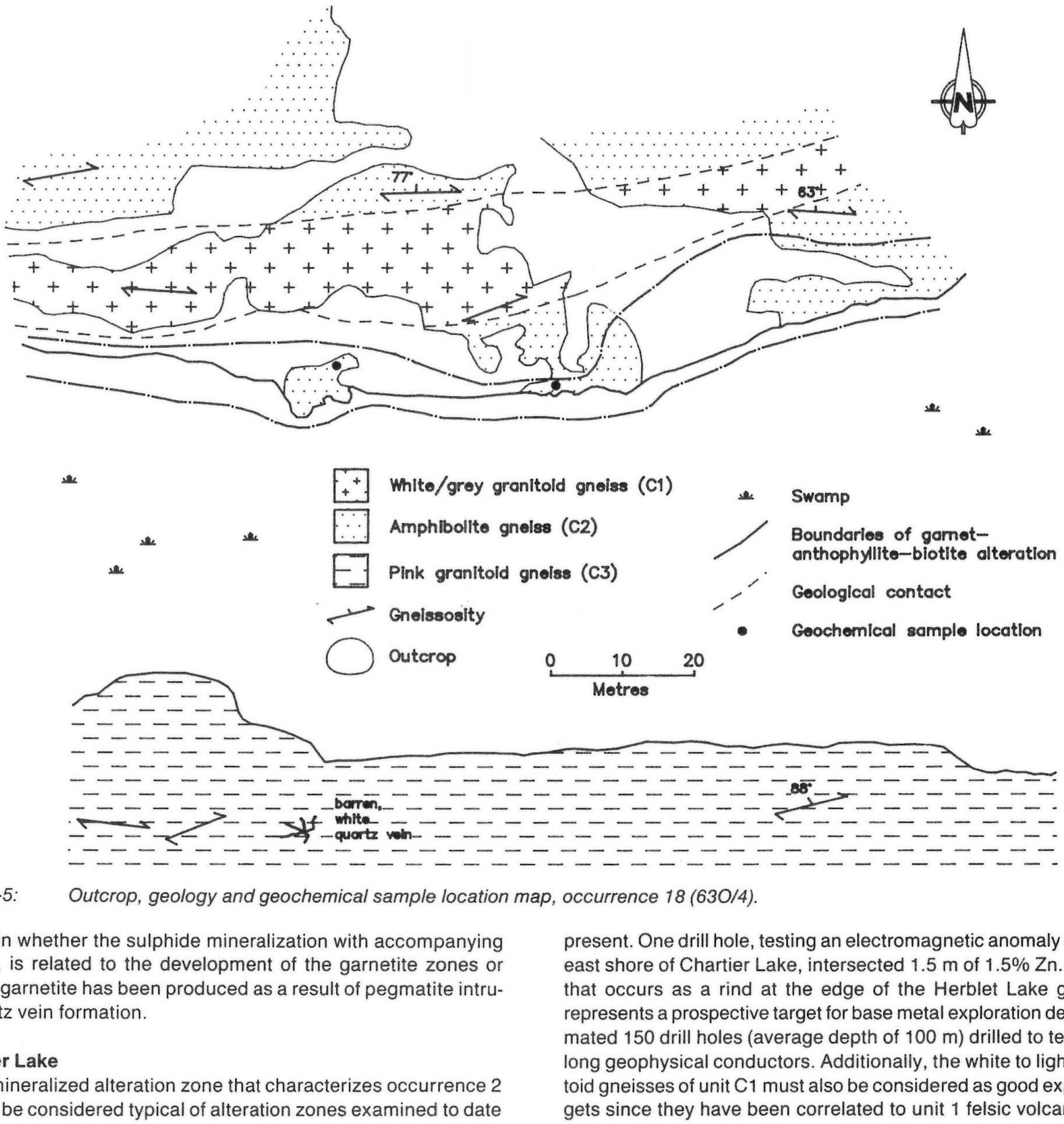

Figure GS-9-5: Outcrop, geology and geochemical sample location map, occurrence 18 (63O/4).

It is uncertain whether the sulphide mineralization with accompanying silicification, is related to the development of the garnetite zones or whether the garnetite has been produced as a result of pegmatite intrusion or quartz vein formation.

III. Pulver Lake

The mineralized alteration zone that characterizes occurrence 2 (63O/4) may be considered typical of alteration zones examined to date in white to grey granitoid gneisses mapped as unit C1 (Bailes, 1975). Occurrence 2 (Fig.GS-9-10, 11) consists of a 1 km long and 0.5 km wide zone of yellow to brick- red rusty weathered garnetiferous magnetite bearing granitoid gneiss. This altered linear zone contains white and less abundant rusty weathered quartz veins up to 0.5 m thick that contain 1% disseminated pyrite and rare chalcopyrite. Approximately 1% pyrite is observed in several locations throughout the altered zone. The rusty weathered zone and the trend of the quartz veins are parallel to gneissosity.

DISCUSSION

Previous exploration in the area including the Herblet Lake and Pulver Lake Gneiss Dome Complexes was primarily undertaken by Hudson Bay Exploration and Development Co. Ltd. during the late 1950's and early 1960's. During this period airborne and ground geophysical surveys were undertaken and anomalies followed up by diamond drilling. This activity resulted in the discovery of the Wim copper deposit (1 million tons grading 2.91% Cu, 0.052 oz/t Au, 0.24 oz/t Ag, trace Zn) hosted by felsic metavolcanic gneiss designated as unit 1 rhyolite (Bailes, 1975). Numerous other conductors were defined within the rhyolite and other rock units. Most of these contained disseminated iron sulphides with traces of sphalerite and chalcopyrite in graphite, although notable exceptions are present. One drill hole, testing an electromagnetic anomaly on the northeast shore of Chartier Lake, intersected 1.5 m of 1.5% Zn. The rhyolite that occurs as a rind at the edge of the Herblet Lake gneiss dome represents a prospective target for base metal exploration despite an estimated 150 drill holes (average depth of 100 m) drilled to test extremely long geophysical conductors. Additionally, the white to light grey granitoid gneisses of unit C1 must also be considered as good exploration targets since they have been correlated to unit 1 felsic volcanic gneisses (Bailes, 1975; Moore and Froese, 1972). The C1 units, that occupy the core of the Herblet and Pulver Lake gneiss domes, are considered to be more coarsely recrystallized equivalents of the finer grained C1 units at Dowling Lake and unit 1 felsic metavolcanic gneiss. The C1 granitoid gneiss on the west edge of the Pulver gneiss dome hosts the Bee zone, a small sub-economic deposit of pyrite, pyrrhotite, chalcopyrite and sphalerite. Accompanying the Bee zone is a 3 m wide and 600 m long zone of predominantly iron sulphides (based on 8 diamond drill holes) manifested at surface as a weak to strong rusty weathered garnetiferous zone. The presence of rusty weathered garnetiferous zones with minor sulphide mineralization in the C1 units described in this and previous reports (Fedikow and Malis, 1988) must therefore be given serious consideration as potential exploration targets for base and/or precious metal mineral deposits. Zones of alteration and mineralization developed within amphibolite gneiss, such as those occurring at Dowling Lake, have not been subjected to the same level of exploration activity as the rhyolites (= C1 gneiss). This may be due to the fact that the Wim and Bee deposits are developed in felsic rocks. Bailes (1975) indicates the possibility of disseminated "Northern Rhodesian-type" copper deposits occurring in Missi Group arkosic strata of the gneiss dome complexes. In addition, amphibolite gneiss (units 6a, C2 and its tectonically deformed equivalent C2a) must be considered as potential hosts for disseminated and massive sulphide

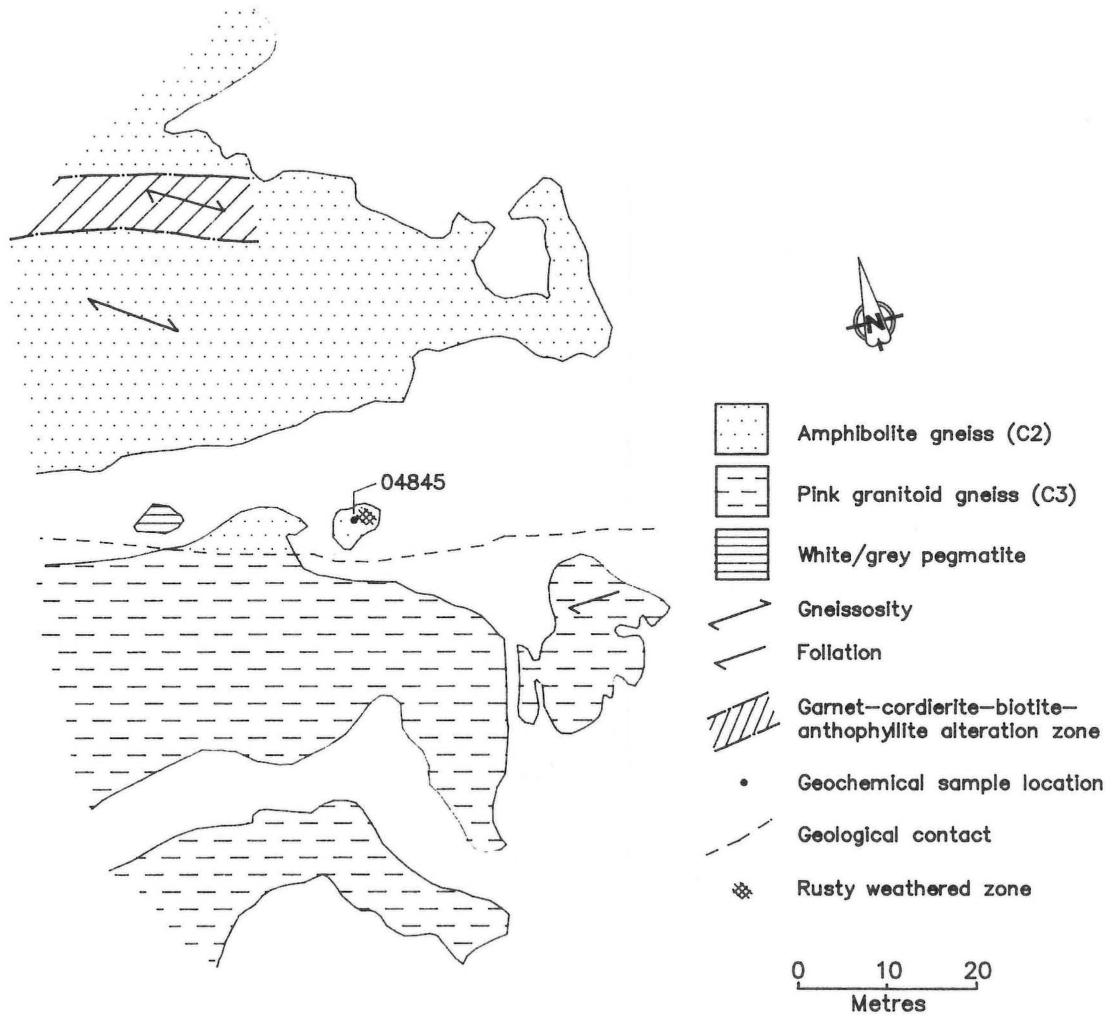

Figure GS-9-6: Outcrop, geology and geochemical sample location map, occurrence 19 (63O/4).

type copper deposits based on the observations at Dowling Lake as presented in this report. This is significant if units C2, C2a or 6a can be demonstrated to be mafic volcanic rocks. The presence of a string of vein and disseminated gold + /- tungsten and base metal deposits (including the Ferguson Au deposit) along the eastern flank of the Herblet gneiss dome in unit 6a indicates potential for base and precious metal mineralization in these rocks. It is noteworthy that extremely long electromagnetic conductors (graphite, iron sulphides, trace sphalerite and chalcopyrite), probably representing the products of chemical sedimentation, have been delineated in this area. Significant airborne and ground geophysical anomalies have also been delineated in arkose and greywacke gneisses at or near the contact with garnetiferous greywacke and migmatite gneiss southeast of Pulver Lake in the vicinity of Jelly Lake. The anomalies have been drilled and are still undergoing active exploration by Hudson Bay Exploration and Development. Accordingly, these same rock units mapped at the periphery of the Herblet and Pulver gneiss domes represent equally attractive base and/or precious metal exploration targets.

Within the Herblet and Pulver Lake gneiss domes, the salmon pink granitoid gneisses designated "C3" by Bailes (1975) contain the least areally extensive mineral occurrences. The occurrences are generally characterized by 1% pyrite in weak shear zones of limited extent, or spatially restricted rusty weathered zones adjacent to white, boudinaged quartz veins. The C3 wallrocks and quartz veins rarely contain visible sulphide minerals.

CONCLUSIONS

Mineralization in the Herblet Lake and Pulver Gneiss Dome Complexes consists of exhalative volcanogenic-type copper and zinc- rich massive sulphide deposits and sulphide facies iron formations both of which are associated with felsic volcanic rocks, epiclastic sedimentary rocks and amphibolites of uncertain origin. These geological environments represent the more "traditional" exploration environments for base and previous metal exploration and offer residual exploration potential particularly since deformation and recrystallization may have disrupted and dislocated mineralization and alteration patterns in the rocks. Disseminated copper and iron sulphide mineralization occurs in association with fine- to coarse-grained felsic gneisses and amphibolite of uncertain origin in the core of the gneiss domes. This style of mineralization is often associated with extensive alteration zones, some of which (garnet-anthophyllite-cordierite) are associated with massive sulphide deposits (i.e. copper-zinc deposits of the Snow Lake camp) situated in metamorphic terranes. Rusty weathered zones with a few percent sulphide minerals in the "core" C1 gneisses may be compared favourably with the surface expression of alteration related to previously discovered massive sulphide-type deposits in C1 gneisses on the west limbs of the Pulver gneiss dome (i.e. the Bee Zone).

A final observation, based on the 1988 and 1989 field examination of the Herblet and Pulver gneiss dome complexes, is the abundance of anthophyllite-garnet-cordierite alteration zones developed in the grani-

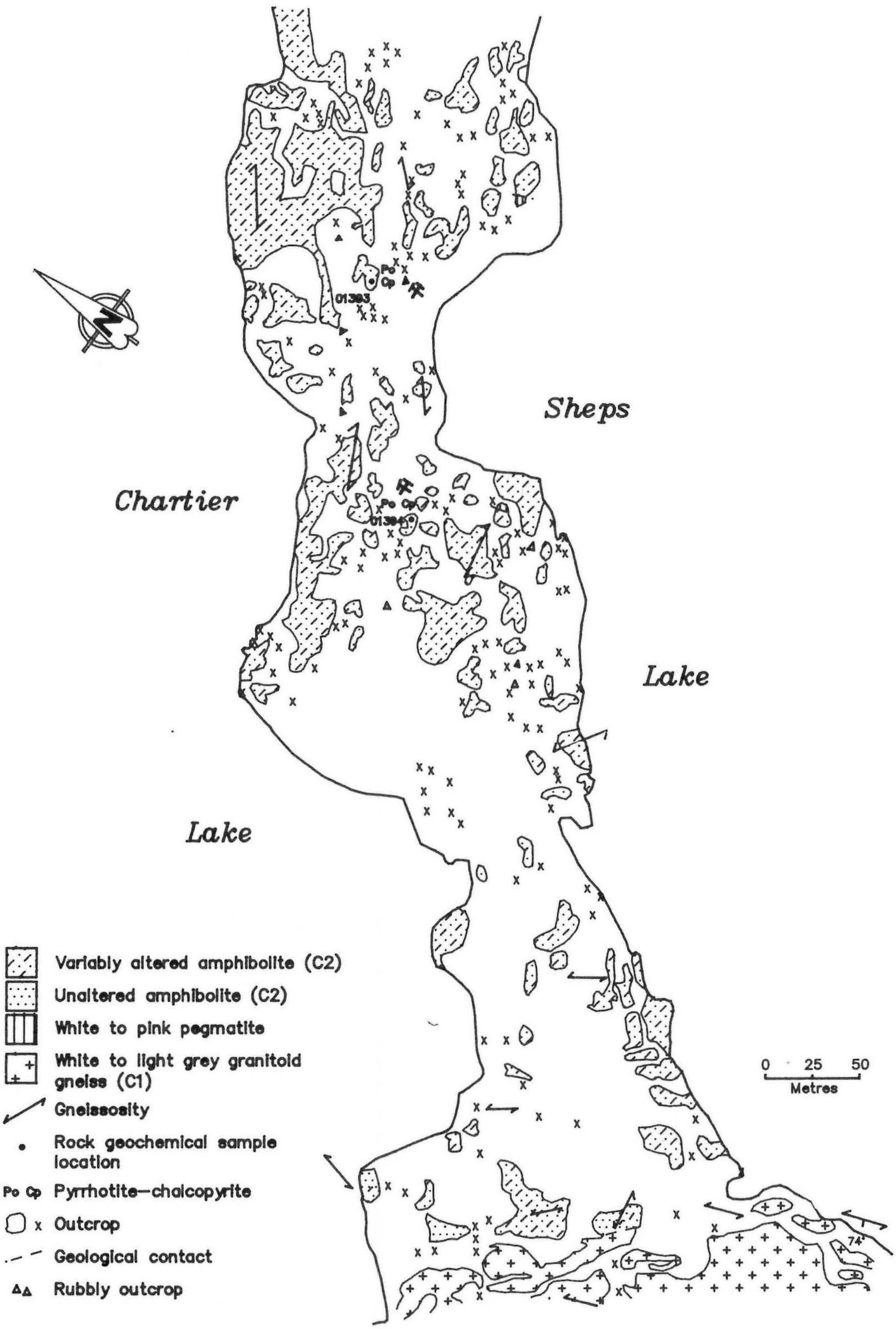

Figure GS-9-7: *Outcrop, geology and geochemical sample location map, occurrence 26 (63O/4).*

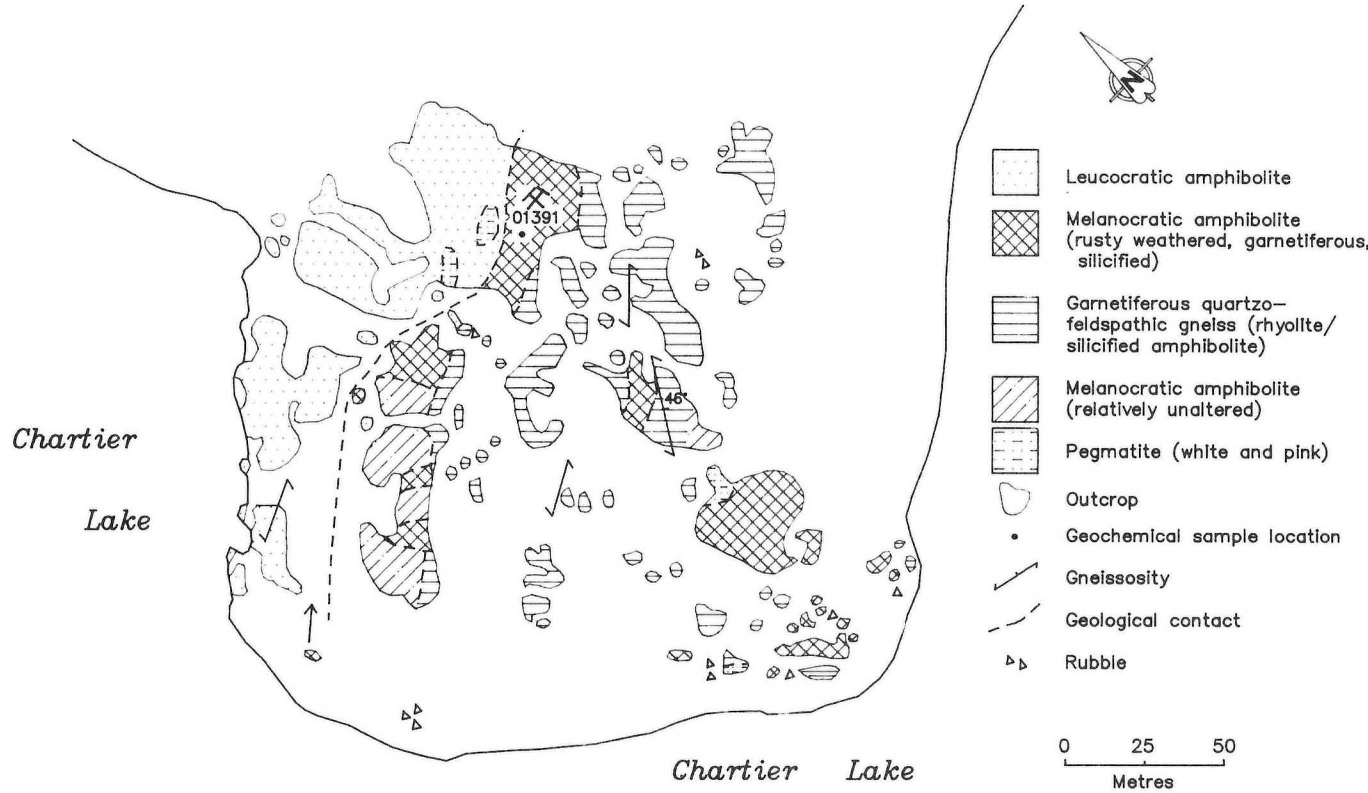

Figure GS-9-8: Outcrop, geology and geochemical sample location map, occurrence 29 (63O/4).

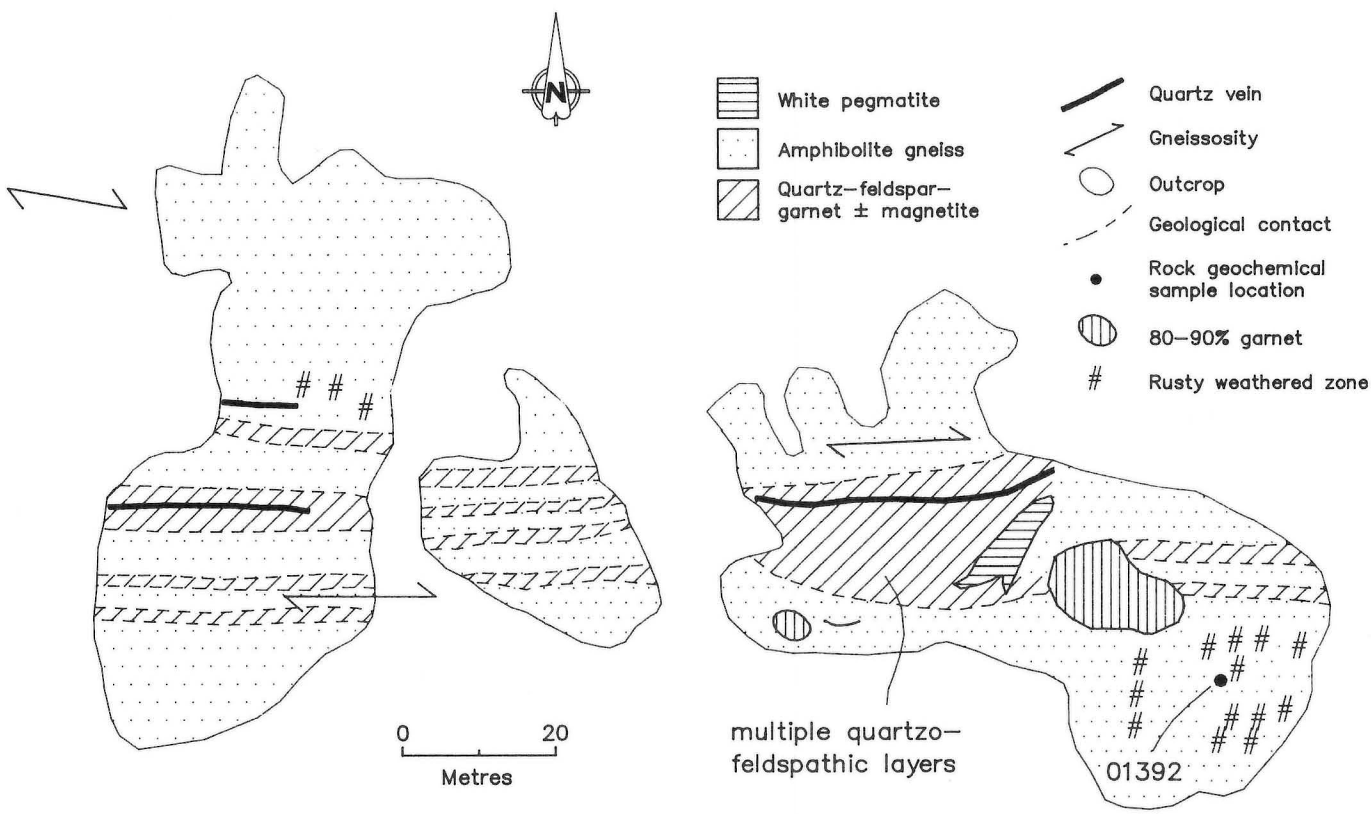

Figure GS-9-9: Outcrop, geology and geochemical sample location map, occurrence 7 (63O/4).

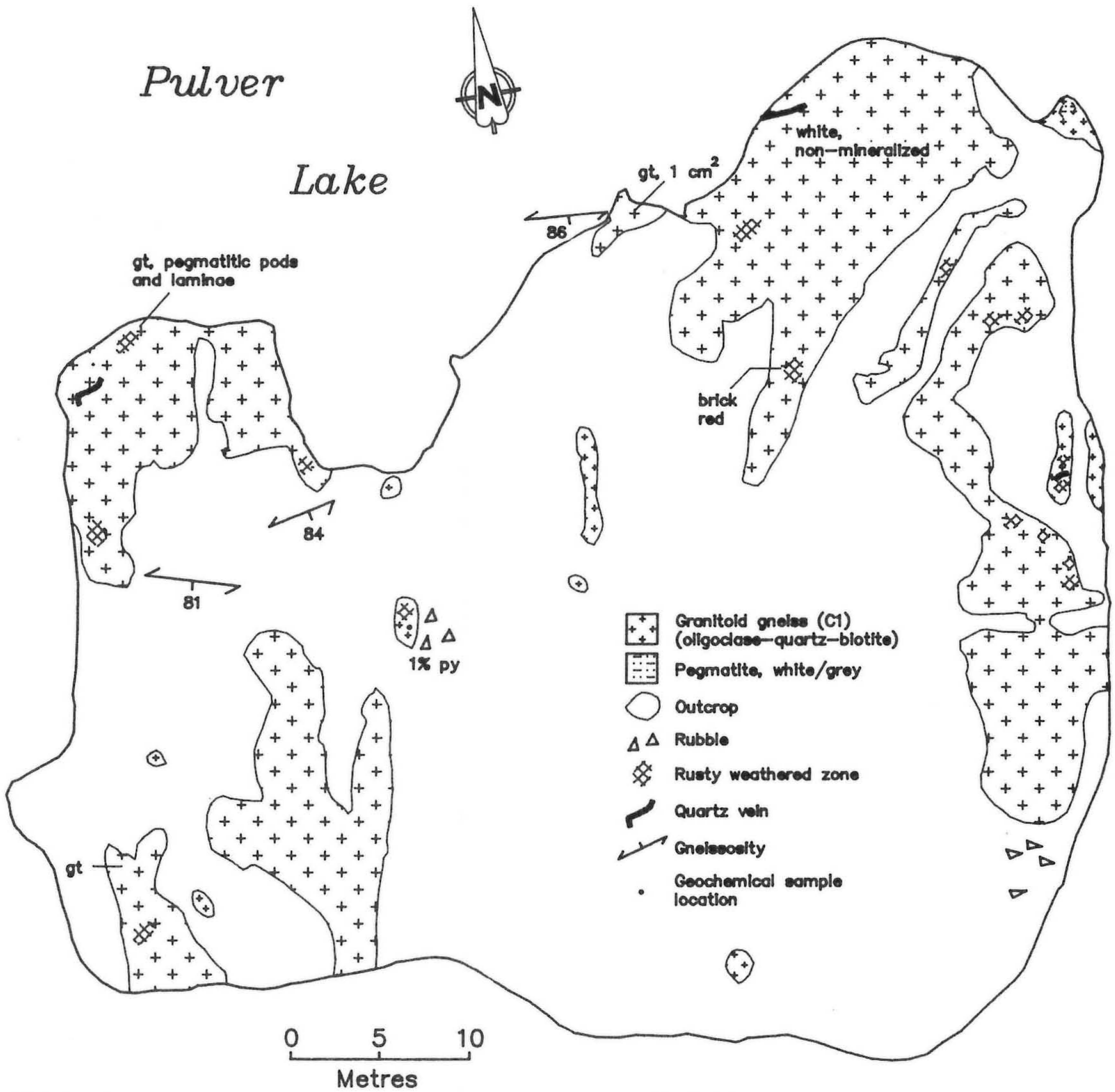

Figure GS-9-10: Outcrop, geology and geochemical sample location map, occurrence 2 (Island) (63O/4).

toid gneisses. These zones represent a significant departure from the usual mineralogies encountered in the granitoid gneisses, and accordingly, represent altered wallrocks produced during fluid flow . Metamorphism at almandine-amphibolite grades would recrystallize altered zones resulting in the coarse grained mineral assemblages observed in the gneiss domes. Many of these mineral assemblages are directly correlated to fluid flow and wallrock alteration accompanying massive sulphide formation in areas such as the Snow Lake mining camp. It is problematic, however, that many of the garnet-cordierite-anthophyllite-biotite alteration zones observed in the gneiss domes generally lack sulphide mineralization. Accordingly, these zones may simply represent alteration unrelated to mineralizing solutions. It is interesting to note that Poulsen and Franklin (1981) documented Na_2O, CaO and CO_2 depletion and MgO, K_2O, FeO, Fe_2O_3 and H_2O enrichment as a result of shearing of trondhjemite (ca. Table 2.1, p. 12) in the Sturgeon Lake area of Ontario. This chemical transfer in the trondhjemite has characteristics similar to those observed in the footwall of massive sulphide deposits (Franklin *et al.*, 1975) and symmetrically about some gold deposits at Red Lake (Hodgson and MacGeehan, 1980) and Timmins (Fryer *et al., 1979*).

Coarse grained assemblages of garnet-anthophyllite-cordierite +/- chalcopyrite and pyrite in felsic and mafic gneisses of the Herblet Lake and Pulver Lake Gneiss Dome Complexes represent the signatures of chemical transfer effected by fluid flow. The fluids may have been derived from products of magmatic crystallization, seawater or metamorphic pressure solution mechanisms (shearing) and may or may not contain base and/or precious metals. The generation of extensive sulphide-poor alteration zones has been attributed to reservoir-type aquifers of regional extent responsible for the transportation of metals in solution and their subsequent deposition at a geologically-suitable site.

The presence of sulphide-poor alteration mineral assemblages in the Herblet Lake and Pulver Lake Gneiss Dome Complexes is considered to represent alteration related to fluid flow +/- base and/or precious metals. A thorough geophysical, geochemical and diamond drilling program is required to ascertain whether or not mineralization is associated with these altered zones.

ACKNOWLEDGEMENTS

We would like to thank Mr. Stan Rodziewicz, Snow Lake resident, for logistical support during the past field season.

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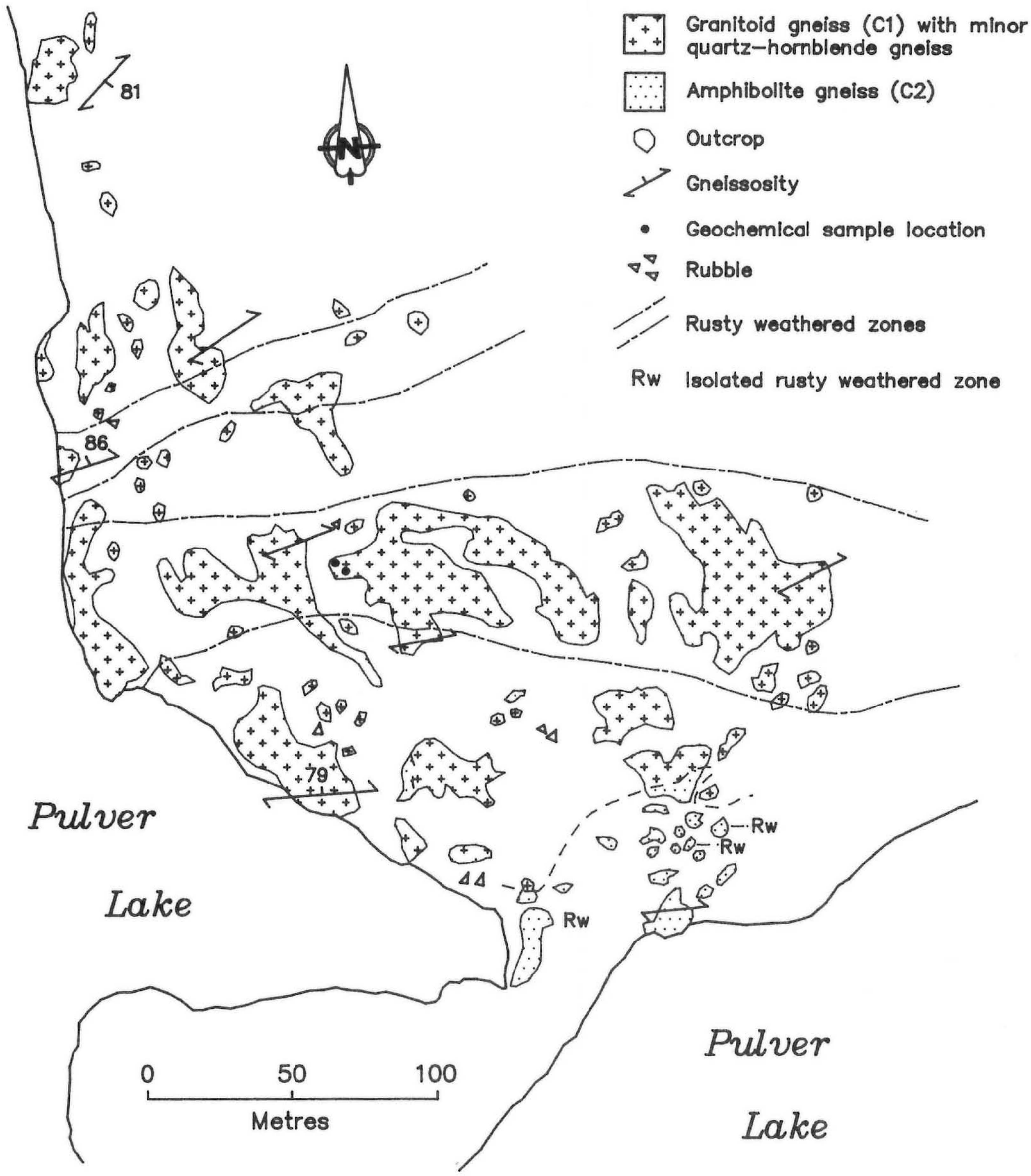

Figure GS-9-11: Outcrop location, geology, rusty weathered zones and geochemical sample locations at occurrence 2 (Mainland) (63O/4).

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GS-10 ROCK GEOCHEMICAL ALTERATION STUDIES AT THE NORTH COOK LAKE MASSIVE SULPHIDE TYPE COPPER DEPOSIT, SNOW LAKE AREA (NTS 63N/16)

by M.A.F. Fedikow and D.R. Lemkow[1]

Fedikow, M.A.F. and Lemkow, D.R. 1989: Rock geochemical alteration studies at the North Cook Lake massive sulphide type copper deposit, Snow Lake area (NTS 63N/16); **in** Manitoba Energy and Mines, Minerals Division, 1989.

INTRODUCTION

A geochemical study of the alteration zone associated with the North Cook Lake massive sulphide type copper deposit was initiated to examine:

(i) the distribution of major and trace elements in the wallrocks to the deposit;
(ii) the usefulness of "immobile" elements to delineate altered and unaltered equivalents of stratigraphic units;
(iii) the quantification of major and trace element fluctuation between altered and unaltered wallrocks; and
(iv) the possibility of developing a statistical guide to mineralization based upon the geochemical and statistical characteristics of altered and unaltered wallrocks.

These studies are being undertaken in association with Edgar Froese of the Geological Survey of Canada who describes the metamorphic petrogenesis of alteration mineralogy at the North Cook Lake deposit (Froese *et al.*, 1989; this volume). A brief description of the deposit and previous studies in the area are also given in Froese *et al.* (1989).

This report describes preliminary results of the geochemistry of the alteration zone and deals primarily with trace element abundances and mineralogical characteristics.

[1]Geological Survey of Canada, Ottawa, Ontario

RESULTS

A total of 153 closely spaced samples were collected from DDH-C85 and analyzed in the following manner:

1. silicate whole rock analysis (wet chemical),
2. total Ni and Cr by fusion; and,
3. multi-element (30) inductively coupled argon fusion atomic absorption spectrophotometry (ICP-AAS). Thin sections were prepared from representative samples collected through the geological cross-section afforded by DDH-C85. Mineral identification and speciation was done by D.R. Lemkow.

TRACE ELEMENT DISTRIBUTION IN THE WALLROCKS

Figures GS-10-1 through GS-10-3 present geochemical profiles for

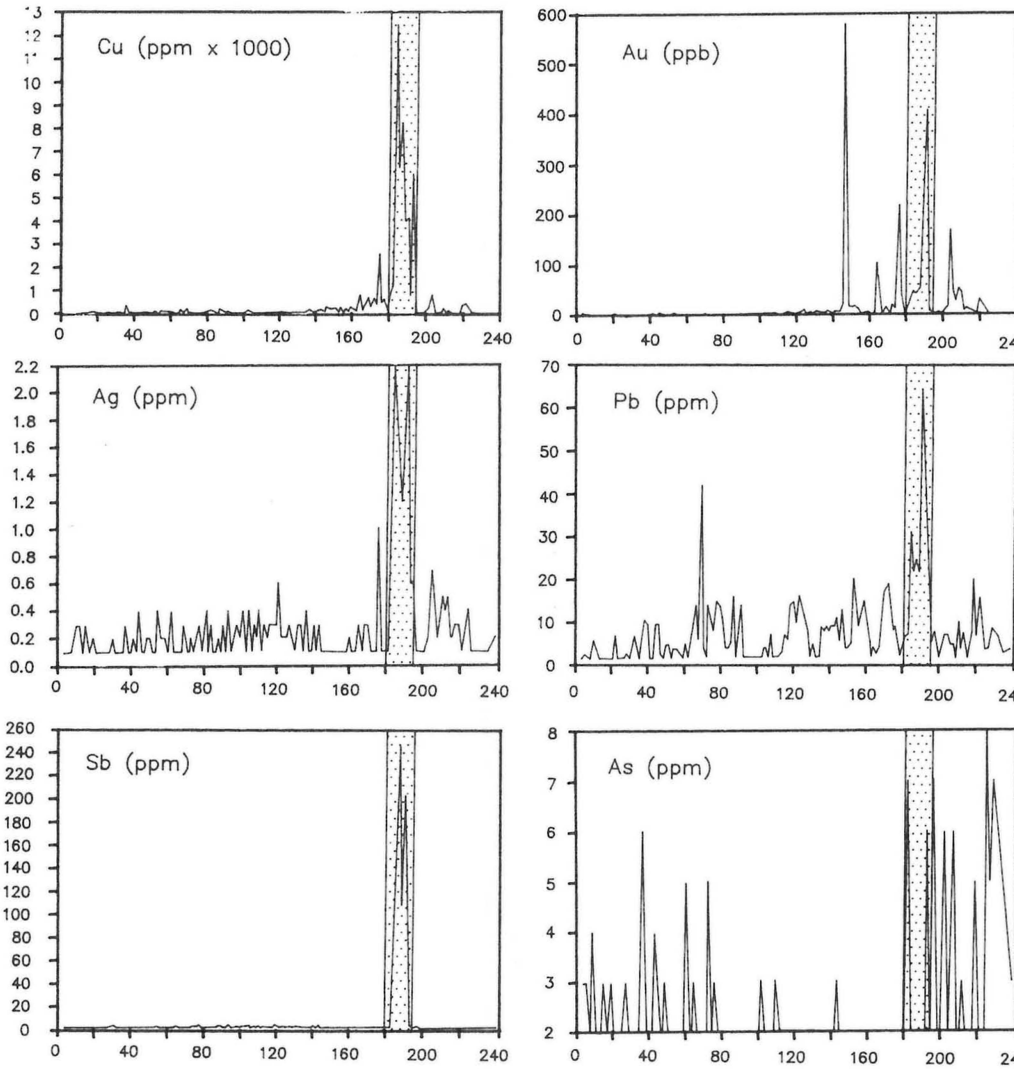

Figure GS-10-1: *Trace element geochemical profiles along DDH- C85, North Cook Lake deposit, Snow Lake area. Partial analyses by AAS following aqua- regia dissolution. Mineralized zone represented by dotted pattern.*

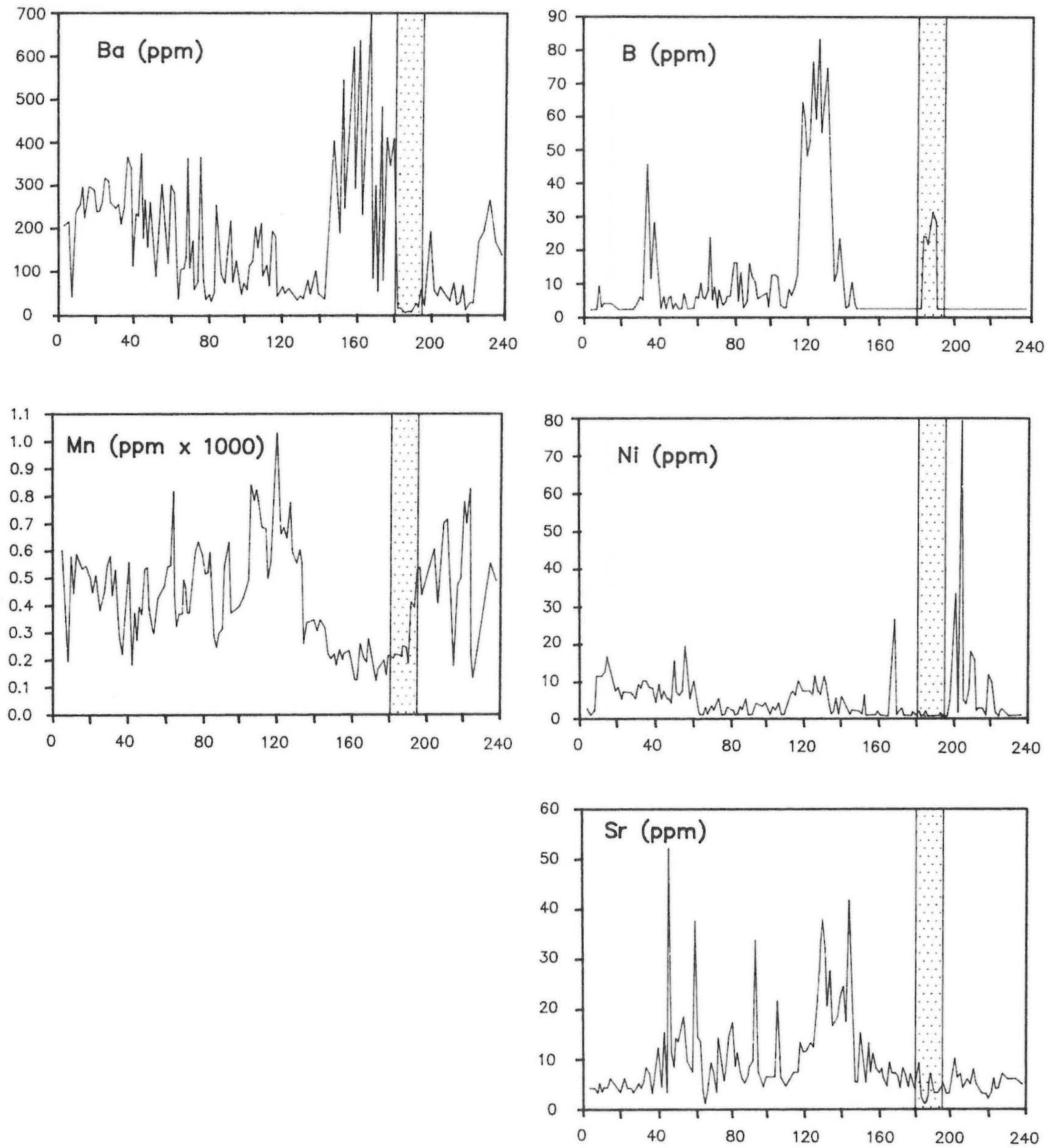

Figure GS-10-2: *Trace and minor element profiles along DDH- C85, North Cook Lake deposit, Snow Lake area. Conventions as in Figure GS-10-1.*

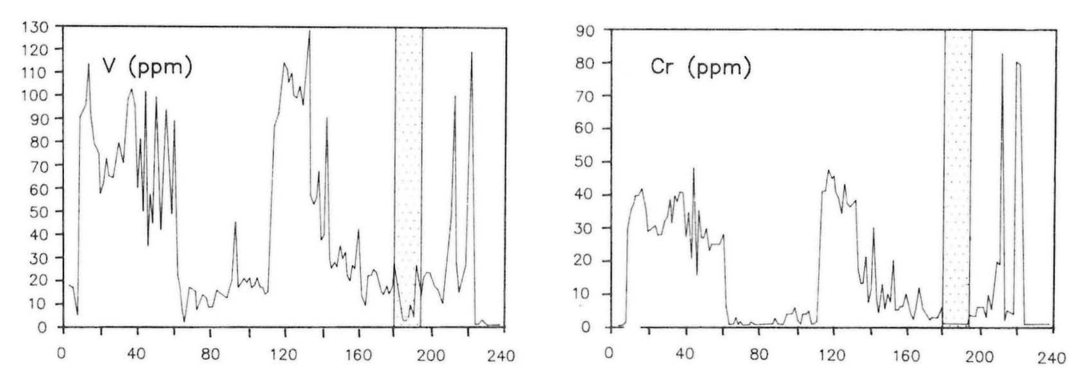

Figure GS-10-3: *Trace ("immobile") element geochemical profiles along DDH-C85, North Cook Lake deposit, Snow Lake area. Conventions as in Figure GS-10-1.*

a wide range of trace elements. A zonality of elements about the mineralized zone is readily apparent. The characteristics of the trace element distribution are summarized in Table GS-10-1. The elements Cu and Au form haloes about the mineral deposit extending up to 85 m on either side of the mineralization. Restricted anomalies, or those confined to the limits of near solid and solid sulphide, are represented by Sb and Pb. Ni contents are characterized by a trough of low values in the mineralized zone, flanked by higher values. The deposit appears to be positioned astride a Mn trough possibly reflecting the zonality of the pH of the geological environment during sulphide versus manganese deposition. Sr is depleted throughout the mineralized zone. Two distinct zones of high Ba and B values are documented on the "up hole" side of the deposit.

Table GS-10-1
Trace element halo characteristics about the North Cook Lake copper deposit, DDH-C85

Element	Profile Characteristics DDH-C85	Background Variation	Anomaly Variation
Au ppb	Enrichment halo (145-223 m; 78 m)	1-13	1-580
Cu ppm	Enrichment halo (135-220 m; 85 m)	4-313	4-12436
Pb ppm	Enrichment halo-restricted (180-195 m, 15 m)	2-42	2-64
Ag ppm	Enrichment halo-restricted (180-195 m, 15 m)	0.1-0.4	0.1-2.2
Sb ppm	Enrichment halo-restricted (183-191 m, 8 m)	2	108-245
Ni ppm	Trough flanked by peaks (165-225 m)	1-16	2-78
Ba ppm	Enrichment halo-displaced 140-180 m, 40 m)	35-367	89-689
B ppm	Enrichment halo-displaced (110-140 m, 30 m)	2-45	2-82
As ppm	Enrichment halo-displaced (180-237 m, 57 m)	2-5	6-8
Fe %	Enrichment halo (90-225 m, 135 m)	0.91-3.74	(1) 2.34-9.56 (2) 29.63 - 32.79

With respect to Fe:
(1) disseminated sulphide mineralization; and
(2) near solid to solid sulphide mineralization

Immobile elements, in Figure GS-10-3, indicate coincident zones of broad peaks and troughs for Cr and V throughout the profile. This suggests these elements will be useful for assessing and quantifying geochemical flux throughout the section, as well as mapping the stratigraphy using trace element geochemistry.

MAJOR ELEMENT DISTRIBUTION IN THE WALLROCKS

Major element variations through the mineralized zone are depicted in Figure GS-10-4. The configuration of certain chemical elements about the North Cook deposit are similar to observations from numerous alteration studies undertaken on massive sulphide-type mineralization and sulphide facies iron formations. Na and Ca are depleted in proximity to the mineralization whereas Al, Mg, K and Fe are enriched. These zones extend for up to 110 m, centred on the deposit. The distribution of Fe is attributed to sulphide deposited during the mineralizing event and preferentially taken into solution by the aqua regia dissolution technique.

MINERALOGICAL CHARACTERISTICS OF THE WALLROCKS

Mineralogical profiles for DDH-C85 are presented in Figure GS-10-5. A spatial relationship exists between the mineralogical and geochemical variations observed in the profiles. With proximity to the mineralized zone, there is a concomitant increase in the abundance of cordierite (+Mg, +Fe, +Al), staurolite (+Fe, +Al), kyanite (+Al), sillimanite (+A1), chlorite (+Mg, +Fe) and a decrease in plagioclase (-Na,-Ca). These variations reflect the presence of mineralization- related alteration in the rocks. The mineral assemblages are developed as a result of element gains and losses and later almandine-amphibolite grade metamorphism. The mineralogical changes are reflected (Fig. GS-10-4) by the major element abundances in the rocks. Major element analyses are based upon a partial dissolution used for the geochemical portion of this study.

This preliminary study has documented the presence of extensive major and trace element and mineralogical anomalies centred on the North Cook Lake copper deposit. Future work will quantify element gains and losses in altered wallrocks, and expand the study to include a wider range of immobile elements that will characterize the stratigraphic units and/or establish a chemical datum from which geochemical flux can be quantified. Additionally, stepwise discriminate function analysis will be applied to the geochemical and mineralogical data in an attempt to derive an "exploration-index" capable of delineating "productive" from "nonproductive" targets in the extensive Cook Lake alteration zone.

ACKNOWLEDGEMENTS

Falconbridge Ltd. is thanked for access to drill core and drill logs. Daryl Hodges is acknowledged for discussions regarding the Cook Lake area.

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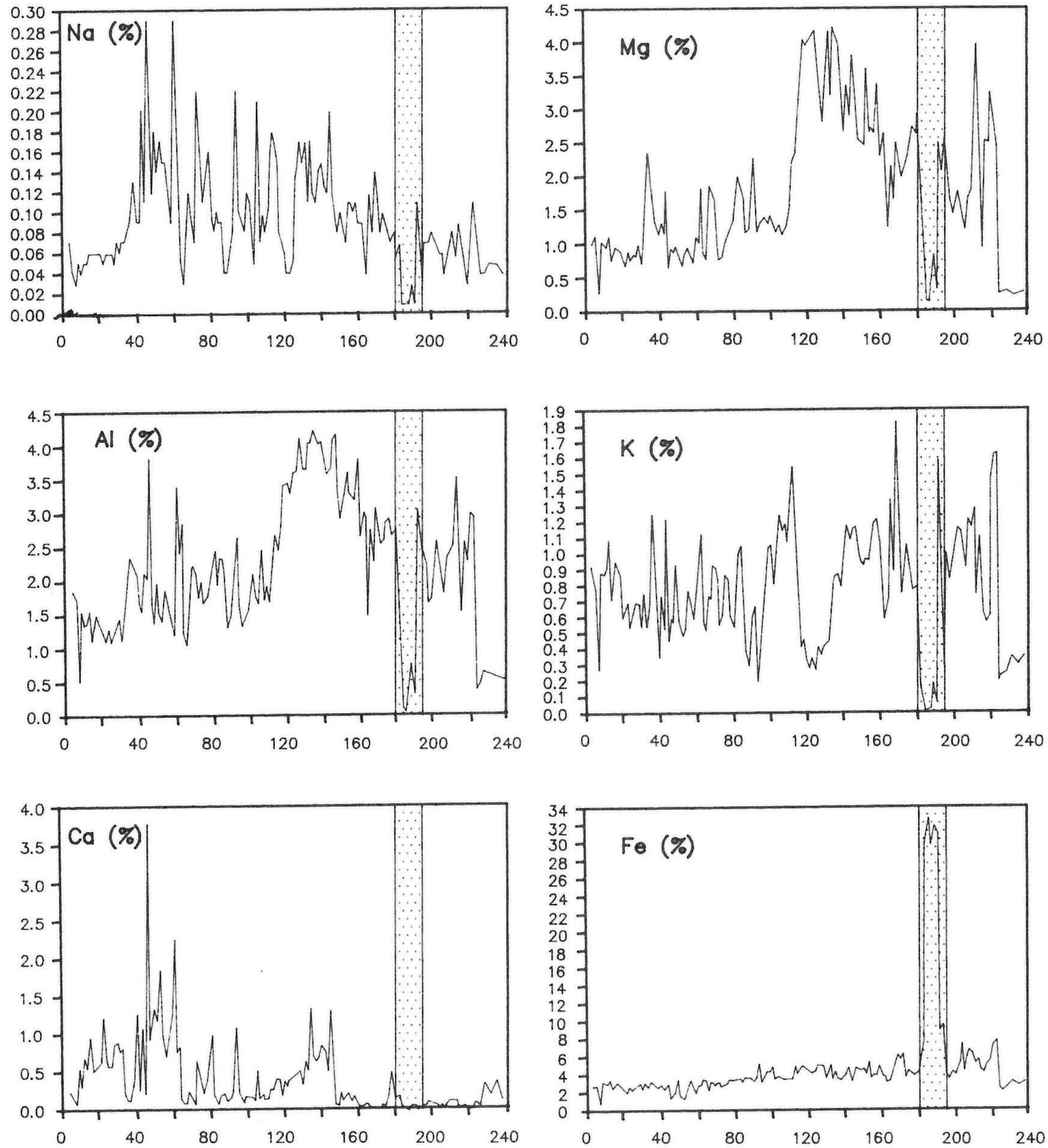

Figure GS-10-4: *Major element geochemical profiles along DDH- C85, North Cook Lake deposit, Snow Lake area. Conventions as in Figure GS-10-1.*

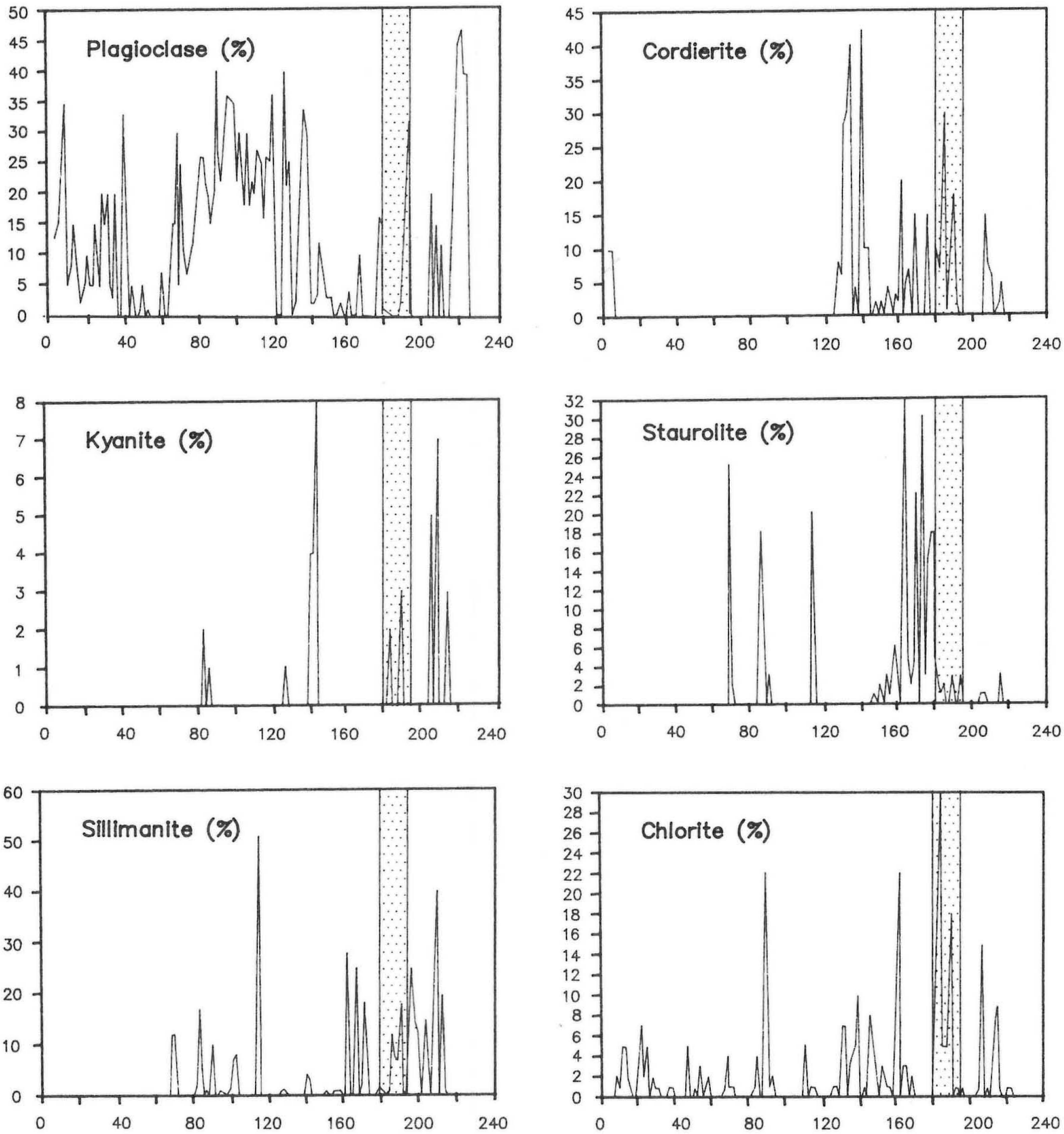

Figure GS-10-5: *Mineralogical profiles along DDH-C85, North Cook Lake deposit, Snow Lake area. Mineral abundances represent visual estimations from thin section.*

GS-11 MINERAL INVESTIGATIONS IN THE KISSEYNEW GNEISS TERRANE

by G. Ostry

Ostry, G. 1989: Mineral investigations in the Kisseynew gneiss terrane; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

Twenty-six occurrences were investigated in the Batty - Moody - Limestone Point lakes area (Fig. GS-11-1). The majority of these were noted by Zwanzig *et al.* (1988). All mineralization comprises disseminated Fe sulphide mineralization with pyrrhotite predominant. Pyrite, where observed, is associated with late thin (normally less than 1 cm), mobilizate veins of quartz-feldspar. Five of the twenty-six occurrences (locations 6,11,12,25,27) are hosted by anthophyllite bearing rocks, five (locations 2,14,16,18,19) are hosted by calcareous amphibolite, six (locations 3,13,15,17,28,29) occur in intermediate gneiss/amphibolite, one (location 1) occurs in graphitic greywacke gneiss and the remainder (locations 4,5,8-10,22-24,26) are hosted by the quartz rich gneisses of Robertson (1953), that are reinterpreted as orthogneiss by Zwanzig and Lenton (1987). With the possible exception of mineralization associated with the anthophyllite bearing layers and the one occurrence hosted by greywacke gneiss it was difficult to determine whether any of these occurrences are formational in nature due to the spotty nature of the mineralization and limited exposure at most occurrences. A list of occurrences and descriptions of mineralization and host rocks is presented in Table GS-11-1. Geochemical analyses of grab samples taken from the occurrences are presented in Table GS-11-2.

PUFFY LAKE

After shutdown of the Puffy Lake Mine near Sherridon, Manitoba in April, 1989, approximately 3 weeks were spent investigating the structure and geology exposed in the underground mine workings. The basic structural and geological interpretations determined during surface mapping and presented by Ostry (1988) remain essentially unchanged. However, the recent underground observations suggest auriferous quartz-sulphide mineralization was emplaced pre-F_2 and mobilization of gold, sulphides and quartz occurred along the F_2 and F_3 axes (lineation) directions.

ACKNOWLEDGEMENTS

Scott Anderson and Hani Khalidi are thanked for their able assistance during the course of the field season. Pioneer Metals Corporation is thanked for their hospitality at the Puffy Lake Mine site during the underground investigation.

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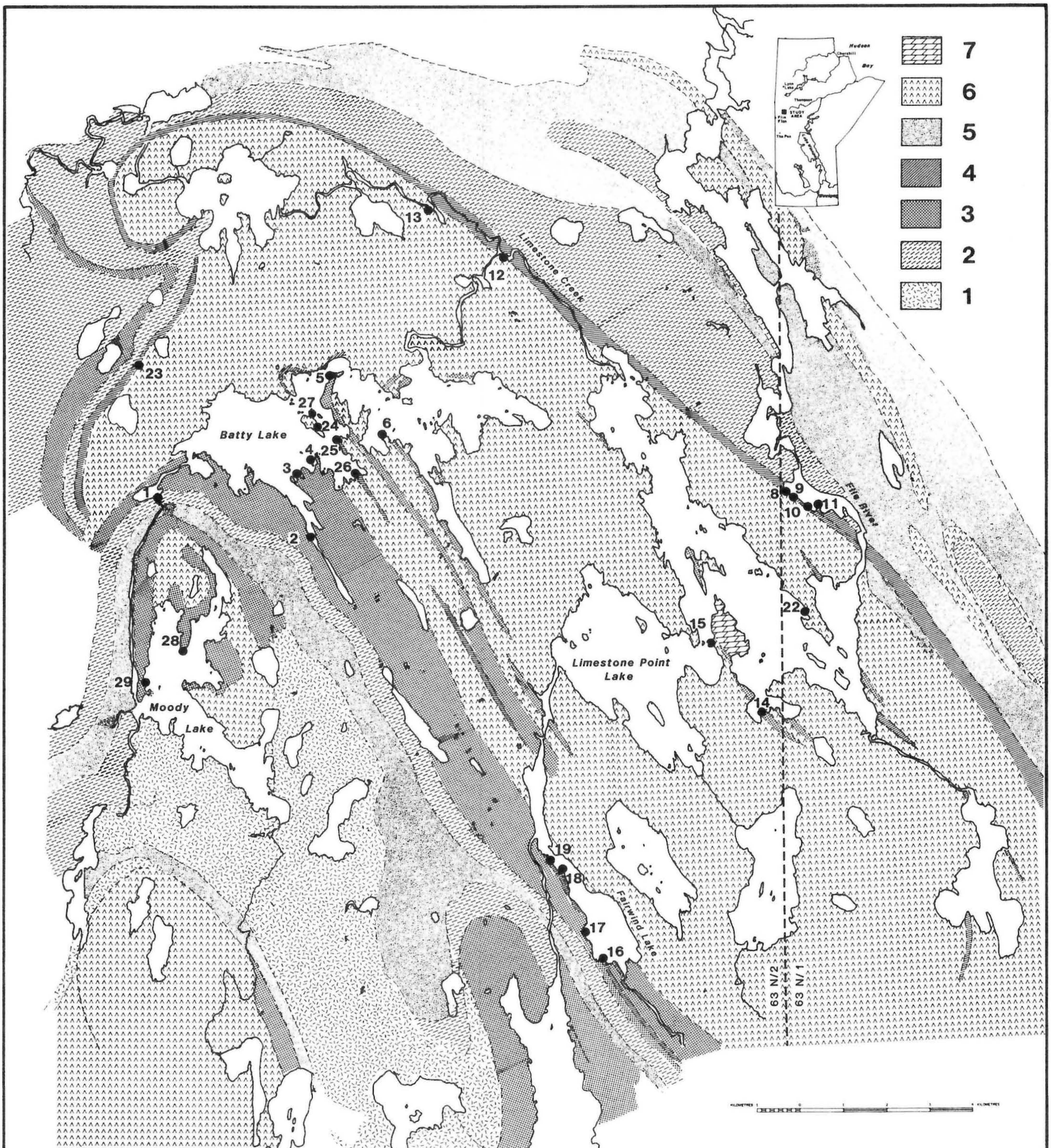

Figure GS-11-1: *Mineral occurrences in the Batty - Limestone Point - Moody lakes area (Parts of NTS areas 63N/1 and 63N/2). Geology base after Zwanzig et al. (1988). Legend: 1. Mafic metavolcanic rock/amphibolite; 2. greywacke gneiss; 3. amphibolite; 4. garnet-anthophyllite rock; 5. quartzofeldspathic gneiss; 6. felsic intrusive rock/orthogneiss; 7. Ordovician dolomite.*

TABLE GS-11-1
SUMMARY OF MINERAL OCCURRENCES INVESTIGATED IN THE BATTY LAKE - LIMESTONE POINT LAKE - MOODY LAKE AREA

Site No.	Location	Nature of mineralization	Thickness/ width	Host rocks	Comments
1	West of Batty Lake, 63N/2	≤1% fg po ± py diss	≈5-6m rusty weathered zone	fg qz-fd-bt-gt-graphite (greywacke) gneiss	sulphides observed in up to 1m wide lenses
2	Batty Lake, 63N/2	≤8% fg po diss within a siliceous qz-fd-bt ± gt ± hb ± di ± carbonate gneiss	not known	fg-mg calcareous amphibolite	possible silicification; adjacent to a pegmatite dike
3	Batty Lake, 63N/2	≤5% fg po diss within a siliceous qz-fd-bt gneiss	≈5m	fg bt-bearing amphibolite	possible silicification; adjacent to a pegmatite dike
4	Batty Lake, 63N/2	≤3% fg po diss	5-10cm	layered mg qz-rich qz-fd-bt-gt gneiss	
5	Batty Lake, 63N/2	≤10% py as fg-mg diss and blebs	≤1m	mg qz-rich qz-fd-bt-gt gneiss	
6	Batty Lake, 63N/2	1-2% fg po and cp diss and up to 20% py in <1 cm mobilizate veins, fracture fillings, and diss	1-2 m	mg-cg qz-fd-bt-gt-at ± sl gneiss within fg-mg qz-bearing amphibolite and garnetiferous hornblendite	garnets within the mineralized zone and hornblendite are pink (Mn-bearing?)
8	File River, 63N/1	≤1% vfg po diss	≈1m	fg-mg siliceous qz-fd-bt ± mt gneiss	possible silicification; adjacent to a pegmatite dike
9	File River, 63N/1	no sulphides observed	10-15cm	layered fg-mg qz-rich qz-fd-bt ± gt ± mt gneiss	rusty weathered
10	File River, 63N/1	<1% fg py diss	not known	mg-cg qz-rich qz-fd-bt-gt-mt gneiss	adjacent to a pegmatite dike
11	File River, 63N/1	1-2% blebs and diss fg po ± cp and up to 5% fg-mg py as diss, blebs and fracture fillings	1-2m	cg qz-fd-bt-gt-at cordierite gneiss within layered (cm-m) qz-rich gneiss	more than 1 mineralized layer
12	Limestone Creek, 63N/2	<2% fg-mg py as blebs diss and subhedral crystals	≈50cm	mg-cg qz-fd-bt-gt-mt-at gneiss	
13	Limestone Creek, 63N/2	<1% fg py diss	not known	fg-mg qz-bearing amphibolite/ hb-fd-qz gneiss	
14	Limestone Point Lake, 63N/2	<1% fg py diss	not known	layered fg gt-, di- and and carbonate-bearing amphibolite	
15	Limestone Point Lake, 63N/2	≤5% py ± po ± cp as fg-mg blebs, diss and fracture fillings	0.1-1m zones within an ≈30m wide zone of deformation	sheared zones within fg-cg qz-rich gneiss, garnetiferous amphibolite and intermediate qz-fd-hb ± bt ± gt gneiss	at contact between Ordovician dolomite outlier and Precambrian rocks; sheared zones are rusty weathered and contain lenses of vfg siliceous rock, mt and carbonate

TABLE GS-11-1
SUMMARY OF MINERAL OCCURRENCES INVESTIGATED IN THE BATTY LAKE - LIMESTONE POINT LAKE - MOODY LAKE AREA

Site No.	Location	Nature of mineralization	Thickness/ width	Host rocks	Comments
16	Fairwind Lake (File River), 63N/2	<2% fg po diss	not known	interlayered fg intermediate hb-fd-qz ± gt ± di gneiss and marble	
17	Fairwind Lake (File River), 63N/2	<3% fg po ± py diss	not known	'cherty' gneiss within fg-mg amphibolite	possible silicification associated with a shear
18	Fairwind Lake (File River), 63N/2	≤2% vfg po; fg-mg py associated with ≤1cm qz-di veins	not known	vfg siliceous qz-fd-bt ± hb-gneiss layer within calcareous amphibolite	
19	Fairwind Lake (File River), 63N/2	≤3% fg po diss and blebs; <5% fg-cg py blebs and subhedral crystals in qz-carbonate-amphibole veins	not known	intermediate-mafic fg hb-fd-bt-qz ≤ di ± carbonate gneiss	exposure is cut by <4cm qz-carbonate-fibrous amphibole veins
22	Limestone Point Lake, 63N/1	<<1% po	exposed for ≈2-4m	mg-cg qz-rich qz-fd-bt-gt gneiss	zone contains ≤60% gt, ≤40% bt, carbonate and calc-silicate minerals; possible shear
23	West of Batty Lake, 63N/2	<<1%po ± py	not known	mg qz-rich qz-fd-bt ± gt ± mt gneiss; possible tonalitic orthogneiss	mineralization is associated with patchy rusty weathered areas
24	Batty Lake, 63N/2	≤2% fg po diss; <1% fg-mg py in thin qz-fd veins	≈2-3m	fg qz-rich qz-fd-bt ± hb ± mt gneiss	possible shear adjacent to a pegmatite dike
25	Batty Lake, 63N/2	<1% fg-mg po diss and blebs	not known	layered fg-cg qz-fd-bt-gt ± at gneiss	
26	Batty Lake, 63N/2	≤3% vfg-fg py ± po diss	exposed for ≈1m	fg siliceous qz-fd-bt gneiss	
27	Batty Lake, 63N/2	<1% vfg-fg py diss, blebs and subhedral crystals	exposed for 1-2m	layered fg-cg qz-fd-bt-at ± sl gneiss	
28	Moody Lake, 63N/2	<1% py ± po	not known	intermediate fg fd-qz-bt gneiss	
29	Moody Lake 63N/2	<<1% py ± po on late fracture surfaces	not known	intermediate fg hb-fd gneiss that contains rare ≤2cm calc-silicate layers	bt-carbonate veins fill late ≤ 2mm fractures

Abbreviations: po = pyrrhotite; py = pyrite; cp = chalcopyrite; qz = quartz; fd = feldspar; bt = biotite; hb = hornblende; gt = garnet; mt = magnetite; sl = sillimanite; at = anthophyllite; di = diopside; vfg = very fine grained; fg = fine grained; mg = medium grained; cg = coarse grained; diss = disseminations

TABLE GS-11-2
GEOCHEMICAL (ICP) ANALYSES OF BATTY LAKE - LIMESTONE POINT LAKE - MOODY LAKE SAMPLES

ELEMENT	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	As	Sr	V	Ca	Cr	Mg	Ba	B	Al	K	AU
	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	PPM	%	PPM	%	PPM	PPM	%	%	PPB
SAMPLE NUMBER																			
1A	8	96	14	81	0.1	27	7	306	11	17	89	0.30	41	0.92	154	4	1.88	0.55	4
1B	6	66	6	87	0.1	22	12	283	5	41	101	0.53	27	1.56	323	17	2.84	0.99	1
1C	5	79	8	75	0.1	17	10	246	9	51	102	0.65	27	1.34	225	7	2.85	0.71	2
2A	3	295	9	57	0.1	28	18	229	10	48	108	1.97	16	0.57	73	11	3.05	0.30	8
3A	3	120	7	36	0.2	18	7	88	5	7	58	0.21	14	0.49	31	2	0.67	0.14	2
3C	13	248	11	201	0.4	97	20	237	5	17	24	1.47	14	0.10	8	3	1.62	0.02	10
4	11	275	2	8	0.1	11	9	79	2	7	46	0.33	9	0.28	15	4	0.45	0.08	1
5	7	269	8	96	0.5	71	17	150	4	8	28	0.29	18	0.12	14	2	0.43	0.05	10
6A	4	550	7	32	0.1	28	39	137	3	4	126	0.15	17	1.25	40	4	1.53	0.29	11
6C	3	198	11	5	0.2	16	13	70	2	2	18	0.03	12	0.19	20	2	0.27	0.04	3
8A	8	58	10	67	0.1	13	4	500	3	2	4	0.02	11	0.94	182	2	1.60	0.97	4
9A	4	55	4	12	0.1	14	5	107	2	6	18	0.12	13	0.13	56	3	0.34	0.05	1
10A	4	70	6	53	0.1	14	9	141	5	4	21	0.03	14	1.51	338	11	2.35	1.00	5
11A	8	188	6	36	0.1	46	17	197	5	2	139	0.13	128	1.67	254	11	2.18	0.77	1
11B	4	473	4	23	0.1	33	28	202	2	5	48	0.33	18	0.73	10	2	1.16	0.04	7
12A	5	130	6	34	0.1	21	12	127	3	2	156	0.05	33	1.63	230	12	2.13	0.81	4
13	1	107	2	19	0.1	8	4	105	2	3	29	0.39	8	0.38	43	2	0.41	0.04	1
14A	2	110	14	16	0.1	12	7	158	3	71	46	3.31	13	0.96	37	19	5.30	0.10	1
15A	2	51	9	56	0.1	11	13	442	4	9	32	0.81	12	0.96	135	14	1.81	0.17	2
15C	2	181	17	58	0.1	12	15	361	3	71	131	3.24	9	1.39	40	15	4.90	0.09	29
15E	3	187	7	201	0.2	28	8	292	3	7	15	0.33	9	0.59	23	13	1.45	0.20	4
16A	2	82	9	20	0.1	10	5	266	7	103	7	11.12	8	0.39	28	7	4.43	0.05	5
17A	7	119	10	83	0.1	36	12	105	7	33	39	2.11	27	0.42	16	9	1.27	0.14	3
18A	15	124	15	130	0.2	41	11	253	5	4	163	0.89	32	0.95	38	14	1.68	0.24	5
19A	2	225	12	8	0.1	62	24	169	6	107	13	5.91	16	0.25	48	10	5.12	0.03	6
22A	2	73	5	109	0.1	8	11	267	2	5	27	0.64	8	1.76	296	15	2.34	0.79	1
23A	2	37	4	15	0.1	9	4	58	2	1	6	0.05	8	0.47	89	6	0.64	0.25	4
24	3	80	3	10	0.1	14	12	109	2	3	66	0.19	15	0.83	124	12	0.77	0.30	3
25A	4	142	9	21	0.1	16	9	98	2	3	30	0.04	20	1.33	243	2	1.86	0.69	4
26A	5	115	6	14	0.1	13	12	116	3	5	32	0.26	12	1.02	72	15	0.93	0.18	4
27A	2	109	5	50	0.1	8	17	123	2	4	66	0.04	7	2.17	131	10	2.49	1.00	7

Sample numbers incorporate the location number. A, B, etc. are used where more than one sample was taken at a location.
Geochemical concentrations of the following elements have not been reported in Table GS -2: Fe,U,Th,Cd,Sb,Bi,P,La,Ti,Na,W.

GS-12 GEOLOGICAL SETTING OF MINERALIZATION IN THE BAKER PATTON FELSIC COMPLEX

by G.H. Gale

Gale, G.H. 1989: Geological setting of mineralization in the Baker Patton felsic complex; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

As a follow-up to detailed geological mapping of the Baker Patton felsic complex (Gale and Foote, 1988; Ferreira, 1988) two weeks were spent logging and sampling drill cores from the Cabin Zone (Fig. GS-12-1). Although the analytical data are not yet available, megascopic textures observed in the cores confirm the hypothesis, presented in 1988, that the ore zone has been displaced by faults. A tuff unit, identified as a stratigraphic marker, should assist in future exploration of the area.

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1988: Geological setting of the Baker Patton alteration zone; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1988, p. 77-79.

Ferreira, K.
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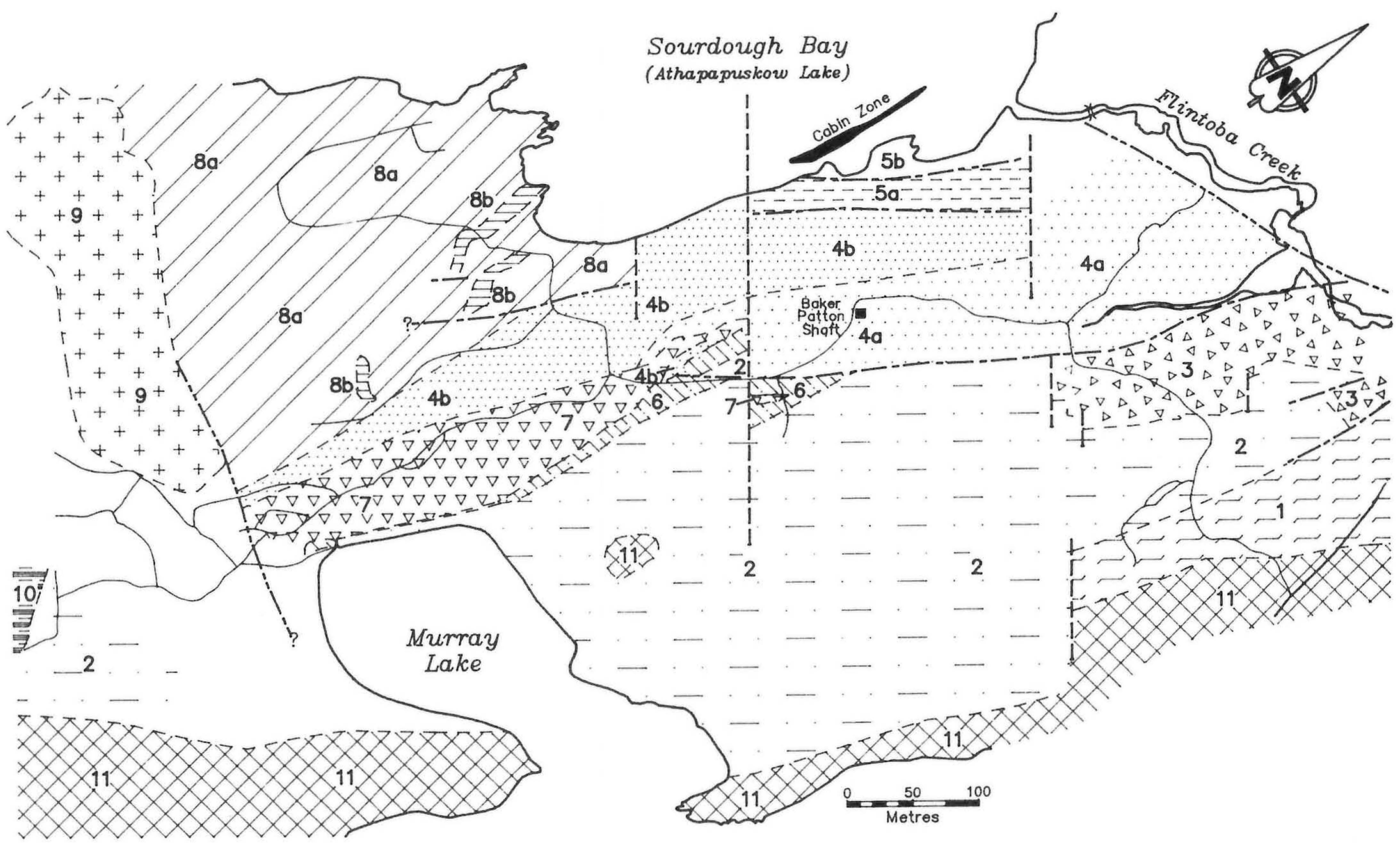

Figure GS-12-1: *Geology of the Baker Patton area. Legend: 1) aphyric rhyolite flows; 2) "Two-quartz" rhyolite breccia; 3) aphyric rhyolite breccia; 4a) rhyodacite flows; 4b) rhyolitic and rhyodacite flows; 5a) rhyolite breccia; 5b) massive rhyolite flows; 6) amygdaloidal rhyolitic flow and sedimentary rocks; 7) heterolithic rhyolite breccia; 8a) rhyolitic and andesitic flows; 8b) quartz-feldspar dyke(?); 9) diatreme; 10) aphyric rhyolite breccia; 11) gabbro. Thick broken lines represent faults.*

GS-13 KISSEYNEW PROJECT: KISSEYNEW LAKE-FLORENCE LAKE AREA

by K.E. Ashton[1]

Ashton, K.E. 1989: Kisseynew project: Kisseynew Lake-Florence Lake area; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The summer of 1989 was spent mapping an area centred 15 km north of Flin Flon along the Saskatchewan border. The study area stretches from Precipice Lake in the Flin Flon volcanic belt across Kisseynew Lake to Florence Lake and eastward to Imperial Lake in the Kisseynew gneiss belt (Fig. GS-13-1). The project represents an eastward extension of a study of the Kisseynew gneiss belt in Saskatchewan as part of the Mineral Development Agreement between the Province of Saskatchewan and the federal government (Ashton and Wheatley, 1985, 1986; Ashton *et al.*, 1986, 1987; Ashton, 1987, in press, in prep.). Much of this area was previously mapped during a geological reconnaissance of the western portion of the Kisseynew gneiss belt in Manitoba by McRitchie (1985, 1986). The purpose of this re-investigation was to correlate the recent findings in Saskatchewan with those of McRitchie.

Foremost of the conclusions from the Saskatchewan work is that the southern flank of the Kisseynew gneiss belt represents the high-grade equivalent of the Flin Flon volcanic belt. The gneiss belt includes a range of amphibolite facies Amisk Group mafic to felsic (Ashton and Froese, 1988) volcanic and derived Amisk Group sedimentary rocks as well as the unconformably overlying Missi Group of terrigenous clastic rocks. Justification for applying the term Amisk Group to the predominantly graphitic wackes associated with the Amisk Group volcanic rocks, rather than Nokomis (Robertson, 1953) as used by McRitchie (1985) or Burntwood River Metamorphic Suite as used for similar rocks in the Kississing and Batty lake areas to the northeast (Manitoba Energy and Mines, 1988; Schledewitz, 1987,1988; Zwanzig and Lenton,1987 ; Zwanzig, 1988), arises from the ability to trace these rocks continuously from the Flin Flon volcanic belt into the Kisseynew gneisses at File Lake (Bailes, 1980a,b) and at Granite Lake in Saskatchewan (Ashton *et al.*, 1987). Rocks termed Sherridon by McRitchie (1985, 1986) have been re-interpreted as either Amisk Group felsic volcanic and volcaniclastic rocks or as Missi Group clastic sedimentary rocks.

The area has been divided into three structural domains:

1. a southern domain of Amisk Group mafic and felsic volcanic rocks and wackes characterized by abundant west-northwest plunging intrafolial folds and moderate northwestward dips;
2. a central domain bounded by two granodioritic sheets(?) converging from Imperial Lake and north of Defender Lake toward central Weetago Bay consisting of a mixture of medium grained, largely diatexitic, Amisk Group volcanic and Missi Group sedimentary rocks and amphibolitic to noritic gabbroic rocks defining complex interference patterns; and
3. a northern domain of isoclinally folded, finer grained Amisk Group and Missi Group sedimentary rocks defining a dome-like structure cored by pink granite (Fig. GS-13-1).

AMISK GROUP

Stratigraphic units established in the Flin Flon volcanic belt remain valid on the south flank of the Kisseynew gneiss belt, but heterogeneous sedimentary rocks and wackes make up a larger component of the Amisk Group due to a broad northeastward facies change (Ashton, in press, in prep.) and possible structural telescoping. In the study area, the transition is expressed by a northward decrease in the abundance of Amisk Group felsic to mafic volcanic rocks (Fig. GS-13-1). As in most areas underlain by volcanic rocks in the Kisseynew gneiss belt, felsic compositions are common.

Mafic Volcanic and Volcaniclastic Rocks

Mafic volcanic and volcaniclastic rocks belonging to the Amisk Group occur only in the southern half of the area and are most abundant in the area between Precipice and Kisseynew lakes where they have traditionally been classified as part of the Flin Flon volcanic belt (Tanton, 1941). Amphibolites immediately north of Precipice Lake contain locally preserved amygdules and abundant prograde epidote alteration in an actinolite(?) rich matrix. To the north, approaching Kisseynew Lake, there is a gradual increase in metamorphic grade marked by the replacement of the green acicular actinolite(?) by stubbier, black hornblende and by the transition from epidote alteration to patchy clinopyroxene- hornblende ± garnet ± carbonate rocks. This transition from greenschist to amphibolite metamorphic facies has historically been used to mark the boundary between the Flin Flon volcanic belt and Kisseynew gneiss belt. Byers *et al.* (1965) placed it through a concordant granodiorite body immediately south of Kisseynew Lake, but detailed mapping suggests that the metamorphic change is gradual and part of a steady increase from sub-greenschist facies south of Flin Flon (Bailes and Syme, 1987; Digel, in prep.) to the amphibolite-granulite facies transition 50 km north in the Sisipuk-Burntwood lakes area (Manitoba Energy and Mines, 1988).

Mafic rocks of the central domain include amphibolites and garnetiferous amphibolites containing 35-70% hornblende, local garnet porphyroblasts up to 2 cm and rare clinopyroxene. Most are homogeneous with grain sizes rarely less than 2-3 mm, which creates some difficulty in distinguishing volcanic rocks from gabbros. Locally carbonatized amphibolites containing clinopyroxene and carbonate occur within a small structural basin southeast of Weasel Bay.

A thin continuous unit of finer grained, layered amphibolite and garnetiferous amphibolite extending through Weasel Bay and Imperial Lake in the northern domain (Fig. GS-13-1) has also been interpreted as part of the Amisk Group mafic volcanic rocks.

Intermediate Volcanic and Volcaniclastic Rocks

Many mafic rocks of the southern and central domains are interlayered on a centimetre scale with more intermediate compositions. Due to the obliteration of primary features, determination of their precursors is difficult. The layered rocks have, therefore, been tentatively grouped with more homogeneous rocks of intermediate composition (CI 20-40). Most are garnet-hornblende gneisses characterized by pink-red garnet porphyroblasts up to 2 cm in the central domain, which commonly exhibit a "bleached" rim free of ferromagnesian minerals.

The intermediate volcanic and volcaniclastic rocks are thought to represent intermediate to altered mafic flows, pyroclastic rocks and possible intrusive equivalents.

Felsic Volcanic and Volcaniclastic Rocks

Felsic volcanic and volcaniclastic rocks are particularly common in the southern domain but were also noted in the central domain southeast of Weasel Bay. They are associated with Amisk Group mafic and intermediate volcanic and volcaniclastic rocks and derived sedimentary rocks. Thin "layers" of amphibolite observed in many outcrops locally exhibit a slightly oblique orientation relative to the regional fabric suggesting an intrusive origin.

Typical felsic volcanic and volcaniclastic rocks weather white-grey or rusty and range from homogeneous to well layered on a centimetre scale. Many are characterized by pink garnet porphyroblasts up to 1-2 cm exhibiting "bleached" quartzofeldspathic rims. They contain up to 20% biotite and/or hornblende and up to 10% garnet in a 1-3 mm quartzofeldspathic matrix. Disseminated iron sulphides are common and are locally associated with cummingtonite/anthophyllite (Fig. GS-13-1). Carbonatized felsic volcanic rocks were also noted near some of the mineralized local-

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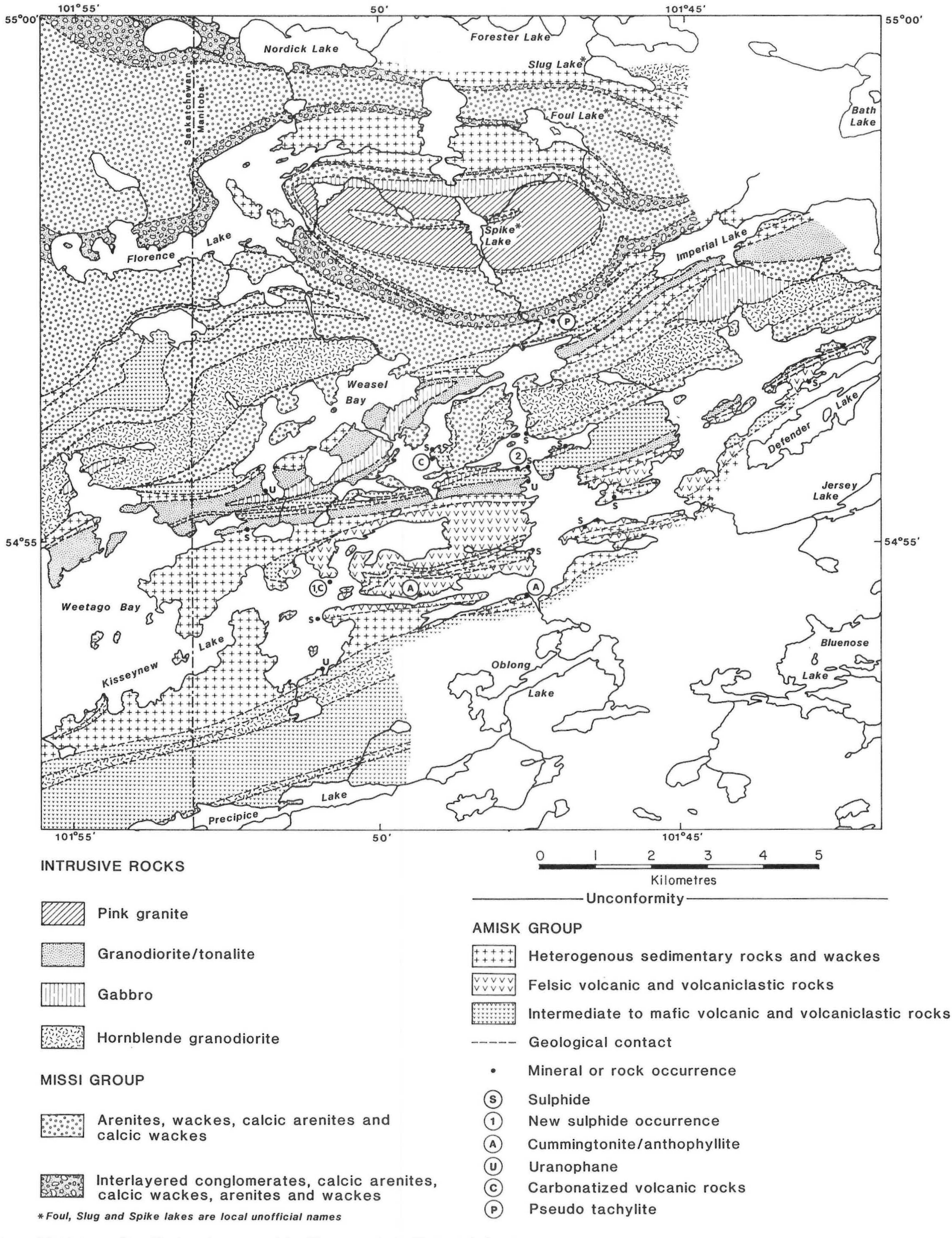

Figure GS-13-1: *Simplified geology map of the Kisseynew Lake-Florence Lake area.*

ities indicating a possible relationship in the alteration processes (Fig. GS-13-1).

The recent interpretation of the Sherridon Group at Sherridon as Amisk Group volcanic and volcaniclastic rocks (Ashton and Froese, 1988) has led to the re-examination of all rocks previously classified as Sherridon Group. In the Kisseynew Lake-Florence Lake area, two sequences of quartzofeldspathic rocks were assigned to the Sherridon Group by McRitchie (1985, 1986). The "Quartzofeldspathic Suite" has been reassigned to the Missi Group, but the "Upper Arenaceous Suite" shares many characteristics of the felsic rocks at Sherridon and at a similar occurrence in the Wildnest Lake area of Saskatchewan. These include: 1) a generally quartz rich nature; 2) the development of "quartz ridges" on weathered surfaces (Froese and Goetz, 1981); 3) the presence of coarse, pink-red porphyroblastic garnet; 4) a spatial association with mafic volcanic rocks, graphitic wackes, calc-silicate rocks and impure marbles; 5) patchy alteration in the form of cummingtonite-garnet and/or cordierite-anthophyllite assemblages; and 6) at least minor sulphide mineralization.

In addition, two new lines of evidence strongly support the interpretation of this suite of rocks having volcanic rather than sedimentary precursors. The first involves the widespread occurrence of quartz "eyes" in rocks of rhyolitic composition at several localities on Kisseynew Lake. The eyes consist of variably flattened to lineated quartz grains that range up to 5 mm in size. They locally compose up to 15% of the rock, which otherwise has an average grain size of 1-2 mm. In the least deformed samples, the quartz grains are roughly equant and weather positively. They occur only in felsic rocks but both homogeneous and layered hosts were observed. In the absence of any plausible mechanism by which these eye-shaped grains could have formed under sedimentary or metamorphic processes, they are interpreted as quartz phenocrysts hosted by shallow intrusive, extrusive and/or tuffaceous rocks. Secondly, a 1 m thick occurrence of felsic volcanic rock was recognized within, and in contact with, mafic volcanic rocks between Precipice and Kisseynew Lakes where there can be no doubt of its volcanic origin. Even there, within the transition between greenschist and amphibolite facies, the very fine grained felsic volcanic rocks resemble rocks of the Sherridon, Wildnest and Kisseynew lakes areas and contain about 10% pink, subhedral, poikiloblastic garnet with "bleached" rims.

This evidence not only implies that the quartz rich gneisses on Kisseynew Lake are Amisk Group felsic volcanic rocks, but that they also represent the "missing link" between the weakly metamorphosed felsic volcanic rocks of the Flin Flon volcanic belt and the more deformed, higher grade quartz rich gneisses at Sherridon and Wildnest Lake in which primary features have been completely obliterated. It is likely that other rocks previously classified as belonging to the Sherridon Group are also in part Amisk Group felsic volcanic rocks and, therefore, should be re-examined.

Heterogeneous Sedimentary Rocks

Structurally and likely stratigraphically overlying the volcanic rocks are Amisk sedimentary rocks, which can be divided into proximal(?) heterogeneous wackes and arenites and more homogeneous graphitic garnet-biotite wackes. Both are common within the southern and northern domains but are absent from the central domain. The heterogeneous sedimentary rocks mainly consist of garnet-biotite-quartz-feldspar ± hornblende wacke, but layers of shale, arenite and amphibolite are common. Most rocks are dark grey and uncharacteristically hard, perhaps indicating a siliceous composition. Typical wackes contain 20-30% biotite but more argillaceous varieties range up to 60%. Garnet is generally only a minor constituent and ranges from pale pink euhedral grains, characteristic of the more homogeneous Amisk Group wackes, to red poikiloblasts up to 5 mm. More calcic compositions contain up to 15% hornblende.

Their heterogeneous nature, association with Amisk Group volcanic rocks, and the presence of minor interlayered amphibolite suggest that the Amisk heterogeneous sedimentary rocks represent a proximal facies derived from the volcanic suite.

Wackes

Amisk Group wackes are particularly widespread in the western Kisseynew Lake area where they represent a relatively homogeneous grey to rusty sequence of easily weathered argillaceous rocks. Typical samples are graphitic and contain 20-30% biotite and 5-10% pink euhedral 1 mm garnet in a fine grained granoblastic matrix. Sillimanite is a minor constituent in homogeneous wackes but is more common in thin, argillaceous layers within better-layered rocks. Subtle variations in mineral proportions and grain size also help to define a weak layering. The layered nature of the Amisk Group wackes has been used elsewhere to suggest turbiditic precursors (Bailes, 1980a,b; Froese and Moore, 1980).

Similar rocks in the Kississing Lake (Schledewitz, 1988) and Batty Lake (Zwanzig, 1988) areas to the northeast have been assigned to the Burntwood River Metamorphic Suite. The Burntwood River Metamorphic Suite as defined by Gilbert *et al.* (1980), modified after the Burntwood River Supergroup (McRitchie, 1974) is a dominantly greywacke shale derived gneiss to migmatite with a minor metavolcanic component. Additional detailed mapping is required to outline the nature of the transition from the mixed volcanic sedimentary sequence of the Amisk Group to the dominantly sedimentary sequence of the Burntwood River Metamorphic Suite.

MISSI GROUP

The Missi Group is most abundant in the northern domain although diatexitic equivalents also occur in the central domain. The basal conglomeratic unit, consisting of interlayered polymictic conglomerate, wacke, arenite and calcic equivalents, is widespread and continuous in the northern domain, but was not recognized to the south. This may be due in part to structural discontinuities but Wilcox (pers. comm., 1989) has demonstrated that even within the Flin Flon volcanic belt, the conglomerate unit is stratigraphically discontinuous. The remainder of the Missi Group consists of wackes and arenites, some of which contain hornblende and have been termed calcic arenites and wackes. Calcic varieties tend to occur near the base of the sequence and appear to represent a transition from the conglomeratic facies to more aluminous and arenaceous compositions. One of the exceptions to this generalization occurs in the area north and northeast of Spike Lake, where both faserkiesel- and hornblende-bearing arenites and wackes are interlayered on an outcrop scale.

Interlayered Conglomerates, Wackes and Arenites

Isolated outcrops of conglomeratic rocks had been previously recognized in the Nordick and Florence lake areas (McRitchie, 1985, 1986; Ashton *et al.*, 1986; Ashton, 1987) but the conglomerate is now known to extend continuously within several isoclinal folds around the Spike Lake structure. Their degree of preservation varies markedly, with the best preserved conglomerates occurring in the most northern localities where the grain size is relatively fine. To the south, grain coarsening due to metamorphism creates difficulties in distinguishing clasts. Furthermore, many of the coarser localities consist of garnet-biotite ± graphite gneisses with the overall composition of wackes. Lenticular layering, best defined by flattened quartzofeldspathic clasts, is the only evidence left of a conglomeratic precursor. This variety differs dramatically from the more typical conglomerates containing abundant mafic material derived from the Amisk Group volcanic rocks and indicates that the Amisk Group sedimentary rocks also provided detritus for the Missi conglomerates within the Kisseynew gneiss belt. There appears to be an upward progression in some localities from the mafic, locally magnetiferous variety rich in volcanic clasts, to the graphitic variety with abundant Amisk Group wacke clasts. In both varieties, fine-grained quartzofeldspathic clasts are the best preserved and other compositions are rare.

Interlayering of Missi conglomerates with wackes and arenites varies from about a metre to tens of metres and conglomeratic units do not necessarily rest directly upon Amisk Group rocks at the unconformity.

Calcic Wackes and Arenites

Calcic wackes and arenites occur interlayered with and stratigraphically above the conglomerates. Typical outcrops are somewhat rounded perpendicular to the dip and are only weakly layered. Most consist of magnetiferous hornblende- biotite-quartz-feldspar ± garnet rocks with an average of about 20% hornblende and biotite. Hornblende may be present in trace amounts or dominate the rock exceeding 30%. Garnet is typically red and anhedral to poikiloblastic but euhedral varieties were also recognized. Magnetite is virtually ubiquitous and generally makes up 2-3% of the rock.

In the Foul Lake area and along strike to the east, calcic wacke and arenite are commonly interlayered on an outcrop scale with faserkiesel bearing arenites. These calcic rocks differ from most in that they consist of zoned, elliptical hornblende ± garnet and epidote ± garnet layers. Smaller equivalents are reminiscent of calcareous concretions in the Amisk Group sedimentary rocks perhaps suggesting that their calcic, thinly layered nature results from a diagenetic process.

Elsewhere the calcic rocks are thought to be derived from calcic arenites. At least some of the hornblende and biotite in these rocks results from the metamorphic recrystallization of lithic fragments in addition to that derived from cement. Taking that into consideration, the relatively low ferromagnesian content of these rocks would suggest that their precursors were more likely arenites than wackes.

Arenites and Wackes

Arenites and wackes generally appear to form the exposed top of the Missi Group in that they locally appear above the calcic rocks and conglomerates. In localities such as Weasel Bay, however, they directly overlie Amisk Group mafic volcanic rocks, leaving some doubt as to whether such contacts are stratigraphic or tectonic.

Due to their extreme hardness, the arenites and wackes also form rounded outcrops perpendicular to the dip and are generally similar to the calcic varieties except for the absence of hornblende. Layering is subtle and on a scale of tens of centimetres to metres. Thin, folded biotite laminae, which occur locally, are interpreted as defining relict foreset beds.

Biotite ranges from 2% in rare feldspathic quartzites to about 20-30% in equally rare wackes. In general, it averages 10-20%. Garnet occurs in about half the rocks examined as does magnetite, which appears less widespread than in calcic rocks. Sillimanite occurs as faserkiesel and thin extensive sheets along foliation planes within thin units commonly associated with feldspathic quartzite and in a widespread area east of Foul Lake. The leucosome derived from the Missi arenites may be white or pink and commonly contains tourmaline and magnetite.

Detritus constituting the Missi Group is believed to be derived from Amisk Group rocks and pre-Missi granodioritic intrusions. The upward transition from calcic to aluminous rocks is broadly correlated with the wearing down of the volcanic terrane and associated unroofing of granodioritic plutons.

INTRUSIVE ROCKS

Hornblende Granodiorite

Hornblende bearing granodioritic rocks occur as deformed plutons and concordant dykes and/or sills throughout the area. Most are white to grey although pink weathering rocks are locally observed. The foliation varies from weak to strong and most are well lineated. The grain size is typically 1-3 mm but this appears to be the result of recrystallization from coarser grained rocks. They contain 5- 15% hornblende and 5-20% biotite with minor garnet near some contacts.

Evidence from Saskatchewan (Ashton, in prep.) indicates that the hornblende granodiorites intrude the Amisk Group, but their relationship to the Missi Group is unclear. They are intruded by pink medium grained to pegmatitic granitic dykes.

South of Kisseynew Lake in the southern domain, two thin, sill-like bodies of hornblende granodiorite locally contain feldspar phenocrysts up to 4 mm in a 1-3 mm matrix. The sills are believed to be the faulted eastern extensions of the Johnson Lake granodiorite in Saskatchewan (Byers and Dahlstrom, 1954; Ashton, 1987).

A similar hornblende granodiorite forms the core of the central domain north of Kisseynew Lake (Fig. GS-13-1). The grain size is typically 1-4 mm and seriate but lineated quartz phenocrysts up to 5 mm were noted at the eastern limit of mapping. Hornblende is absent within phases near the western contact and at patchy occurrences within the pluton suggesting a composite nature or the presence of a complex border zone. Along its southern contact where the pluton margin is well exposed, thin amphibolitic layers and intermediate to mafic schlieren are common.

The hornblende granodiorite extending westward from northern Weasel Bay also contains more leucocratic, hornblende free phases along some contacts. It is believed to represent the eastern extension of the Tyrrell Lake granodiorite in Saskatchewan (Byers and Dahlstrom, 1954; Ashton, 1987). In the Weetago Bay area 1-2 km west of the Saskatchewan border, quartz dioritic and gabbroic phases are common within the granodiorite.

A hornblende granodiorite body in the Slug Lake area (McRitchie, 1985) is similar to the Tyrrell Lake granodiorite in that it contains some quartz dioritic to gabbroic phases.

Gabbro

Gabbroic rocks occur in both the central and northern domains. In the central domain, they include the Imperial Lake norite (Bateman and Harrison, 1945), which has been described in some detail by McRitchie (1986) and was not re- examined during this study. McRitchie's (1986) contention that the norite is intrusive into rocks interpreted during this study as part of the Missi Group supports a potential correlation with a suite of rocks including the 1824 ± 2 Ma (Ashton *et al.*, in prep.) Neagle Lake Pluton in Saskatchewan (Byers and Dahlstrom, 1954; Ashton *et al.*, 1987), the Boundary Intrusions (Syme and Forester, 1977; Bailes and Syme, 1987) and 1830 + 11/-5 Ma (Gordon *et al.*, 1987) rocks classified as enderbites 50 km to the north in the central part of the Kisseynew gneiss belt (Manitoba Energy and Mines, 1988).

Other gabbroic rocks in the central domain consist of black medium grained amphibolites and garnetiferous amphibolites that are not easily distinguished from coarsened mafic volcanic rocks. In general, the rocks classified as gabbroic exhibit little or no evidence of layering and contain phases with recrystallized plagioclase phenocrysts which were up to at least 5 mm in size prior to flattening.

A thin sill-like body extends eastward from the Weetago Bay area just north of the southern boundary of the central domain (Fig. GS-13-1). It is a composite intrusion with numerous phases including a well foliated plagioclase porphyry that contains 15% plagioclase phenocrysts flattened into 4x10 mm lenses in a 1 mm matrix of 35-50% hornblende, 0- 5% clinopyroxene and plagioclase. Other phases include amphibolite dykes containing up to 70%, 4-8 mm hornblende and porphyroblastic dioritic or anorthositic gabbroic rocks with up to 15% clinopyroxene, 15-20% hornblende, rare garnet and trace iron sulphides in a 1-2 mm matrix. The sill intrudes the Amisk Group volcanic suite but its relationship to the Missi Group and the Imperial Lake norite is unknown. It is intruded by dykes of granodiorite/tonalite and pink pegmatite.

The northern gabbroic pluton of the central domain is a more homogeneous, medium-grained intrusion containing only rare plagioclase phenocrysts. It appears to be totally enclosed within a granodiorite/tonalite pluton.

In the northern domain, gabbroic rocks are restricted to the boundary of the Spike Lake pink granite and appear to form a continuous border. It is generally a homogeneous medium- grained amphibolite or garnetiferous amphibolite with rare plagioclase-phyric phases exposed immediately north of Spike Lake (Fig. GS-13-1). The gabbroic boundary was also observed between the pink granite and Missi Group calcic wackes in the core of the Spike Lake structure.

Granodiorite/Tonalite

Hornblende free granodioritic and/or tonalite rocks make up most of the two plutons bounding the central domain and also occur as numerous, thin, sill-like bodies particularly well exposed on many of the points and islands on Kisseynew Lake (Fig. GS-13-1). Typical rocks are grey, but pink varieties were also observed. Grain size ranges from 1-3 mm, but local heterogeneities include feldspar phenocrysts and seriate phases with grain size ranging up to 4 mm. They contain 5-15% biotite with rare hornblende, garnet and/or magnetite in contact zones.

The granodioritic/tonalitic rocks intrude the Amisk Group but were not observed in direct contact with the Missi Group. They are intruded by medium-grained to pegmatitic granitic rocks. The sheet-like granodioritic/tonalitic intrusion forming the southern boundary of the central domain is largely pegmatitic in the centre of the area and is represented by an injection migmatite developed in Amisk wackes at the eastern limit of mapping. Near the Saskatchewan border, its northern contact with rocks of the central domain is sharp forming a distinct topographic lineament.

The larger granodioritic/tonalitic pluton forming the northern boundary of the central domain contains abundant gabbroic material. A pink-grey porphyritic phase in the Imperial Lake area contains up to 15%, 1 cm feldspar phenocrysts in a 2-3 mm groundmass.

These two large granodiorite/tonalite bodies converge in the Weetago Bay area and are thought to extend westward to a similar hornblende free granodioritic pluton in the Deadhorse Lake area of Saskatchewan (Byers and Dahlstrom, 1954; Ashton, 1987).

Pink Granite

The Spike Lake pink granite is unique in colour and composition to the area. It forms the core of the Spike Lake structure but is itself cored by Missi Group calcic rocks. The border zones of the pink granite are heterogeneous with aplitic, medium grained and pegmatitic phases all in approximately equal but variable proportions and displaying gradational contacts. Gabbroic rocks rim the granite and locally occur within it as layers and schlieren. These give way to 10-15% streaks of hornblende and hornblende aggregates up to several cm long and 5 mm wide at some distance from the contact. The aplitic phase is typically sugary and 1-2 mm in grain size with 0-5% biotite and 0-2% magnetite.

The pegmatitic and aplitic phases become less abundant with increasing distance from the contacts. They grade into the more homogeneous, medium grained, main phase containing 5- 10% partially chloritized biotite aggregates up to 1 cm, 25- 35% quartz and 0-3% 1-4 mm partially hematitized magnetite in rocks varying from 2-5 mm in grain size. Subtle variations in biotite grain size provide most of the observed heterogeneities. Many outcrops display folding but the weak fabric makes structures difficult to measure.

The age relationships of the pink granite are unclear. The general increase in grain size towards the core of the pluton and the abundance of pink pegmatitic granite dykes in adjacent Missi Group rocks suggests an intrusive contact but the role of the gabbroic border is not fully understood. The granite is similar in composition and appearance to the late, pink, medium grained to pegmatitic granite dykes suggesting that the two might be co-magmatic. The pink 1773 $\pm$ 9 Ma (Bickford *et al.* 1987) Jan Lake granite in the Hanson Lake Block of Saskatchewan has a similar relationship with the late pegmatites.

Pegmatitic to Medium-Grained Granite

Pink granitic and pegmatitic dykes are common throughout the area and are particularly well exposed on points and islands in the large lakes. The only outcrops in poorly exposed areas commonly consist of pegmatitic dykes with minor supracrustal material along the edges of the outcrop. Large outcrops generally exhibit a gradation from medium grained granite to pegmatite. Most contain only biotite, quartz and feldspar, but garnet and tourmaline are common accessory phases.

In Saskatchewan, at least 2 ages of pegmatitic granite have been determined by U/Pb dating of monazites. Preliminary dates of 1805 and 1767 Ma (Ashton *et al.*, in prep.) indicate that they likely represent the latest igneous activity in the region.

METAMORPHISM

All of the rocks studied have been metamorphosed to amphibolite facies with the possible exception of amphibolites in the Precipice Lake area where amygdules and prograde epidote alteration are preserved in actinolite(?) $\pm$ hornblende schists. The grade increases steadily northward from Precipice Lake so that garnet-hornblende assemblages characterize mafic rocks well south of Kisseynew Lake.

In the absence of obvious phase changes, further increases in the metamorphic grade may show up as a coarsening in grain size. Gradations from less than 1 mm in most of the supracrustal rocks to 1-2 mm are common throughout the area but particularly so in the vicinity of the Amisk-Missi unconformity. Rather than resulting from an increase in metamorphic grade, however, this is more likely attributable to original grain size and compositional changes associated with weathering at the unconformity prior to metamorphism.

The central domain is, however, partly defined on the basis of abnormally coarse grain size. Virtually all of the supracrustal rocks display this coarser nature, making their classification difficult. The transition is best observed in the Missi Group calcic wackes southeast of Weasel Bay. At their eastern extent, they are typical supracrustal rocks with an average grain size of less than 1 mm although they contain garnet porphyroblasts up to 5 mm. To the west, they contain well-lineated segregations of leucosome with garnet poikiloblasts up to 2 cm surrounded by medium grained white quartz and feldspar. Hornblende porphyroblasts up to 1 cm are locally distributed. Five hundred metres westward, the rock consists predominantly of this leucosome with layers of gneiss containing 2 cm hornblende porphyroblasts and thin melanosome approaching garnetite in composition. The ultimate product of this progression is the development of a white, medium-grained diatexite of quartz dioritic composition. Only subtle variations in colour index and grain size, and the presence of rare garnetite melanosome provide support for their supracrustal classification.

Amisk Group volcanic rocks defining a small interference structure south of the Missi Group calcic wackes exhibit a similar transition to diatexites but virtually all other rocks within the domain are uniformly diatexitic.

The central domain, therefore, appears to represent an area of somewhat higher metamorphic grade and perhaps a deeper level of exposure.

STRUCTURE

The gneissosity and co-planar regional foliation (D_1) are gently to moderately north-to north-northwest dipping except in the hinge zones of folds. No linear fabrics related to this D_1 deformation were observed. D_2 structures include isoclinal to open, gently west-northwest-to northwest-plunging, predominantly southwest verging folds and co-linear extension and/or intersection lineations. A moderately northeast-dipping axial planar foliation is locally defined by micas and/or sillimanite. The megascopic fold defined by felsic volcanic and volcaniclastic rocks on Kisseynew Lake is a D_2 structure.

A second, less common set of isoclinal to open folds and co- linear extension and/or intersection lineations (D_3) is developed approximately orthogonal to the D_2 structures, plunging gently to moderately north to northeast. A moderately to steeply northeast- to southeast-dipping axial planar fabric is only locally developed.

In the northern domain, D_2 and possibly D_3 fabrics are overprinted by the gently north-plunging structure centred on the Spike Lake pink granite. D_2 and D_3 fabrics are difficult to distinguish in the area due to rotation about the granite, suggesting that the structure is at least late- to post-D_2 in age. At the west end of the structure, isoclinal to open, gently north-northwest plunging D_2? folds show a northward rotation into gently north-northeast plunging orientations. A gently to steeply northeast dipping axial planar fabric is locally developed. At the east end of the structure, gently northeast plunging folds, with rarely developed, gently to moderately northwest dipping axial planes, are rotated northward into north-and northwest-plunging orientations.

McRitchie (1986) drew attention to the northeast dip of planar fabrics and the moderate north-northeast plunge of lineations at both the eastern and western closures of the structure and interpreted it as "a highly compressed Z folded megaboudin lying *en echelon* and central to satellite pods of granitoid gneisses at Slug Lake and Weasel Bay." One problem with this model is that, although the Weasel Bay pluton also contains a gently northeast plunging linear fabric, both it and the Slug Lake plutons are hornblende granodiorites and quite distinct from the Spike Lake pink granite.

Further work is required to properly understand the Spike Lake structure but an alternate interpretation is that it represents a sheath fold. Regional ductile shearing is inferred by the coarser, higher grade nature of the granitoid bounded, diatexitic central domain to the south. The possibility that the entire central domain is tectonically emplaced from deeper levels along a thrust fault now represented by one or both of the bounding granodiorite bodies cannot be dismissed. The fold interference pattern within the central domain could be related to D_2-D_3 interference but could be equally well explained with a sheath folding model. Furthermore, pseudotachylite was observed in Missi Group rocks near the central-northern boundary contact west of Imperial Lake (Fig. GS-13-1) pseudotachylite in a similar stratigraphic setting, north of Lobstick Narrows about 20 km to the east, may be part of the same zone and would indicate regional shearing prior to at least some of the folding. Following this sheath folding model, the northeast plunge of the structure would imply a southwest vergence to the shearing similar to that inferred from the regional D_2 fold structures.

Fractures and hematite, chlorite and epidote alteration suggest late, brittle, layer-parallel faulting along many of the east-west bays and channels in Kisseynew Lake (McRitchie, 1985) but significant displacements were not recognized.

ECONOMIC GEOLOGY

Previously recognized sulphide showings have been described and classified by McRitchie (1985) and Gale and Eccles (1988). New showings are listed in (Fig. GS-13-1) and include the following:

1. disseminated pyrrhotite in layered grey to rusty quartzofeldspathic gneiss with minor interlayered amphibolite and associated carbonate. The gneiss is part of an Amisk felsic volcanic and volcaniclastic sequence and may represent chemical sediments or altered felsic volcanic rocks.
2. rusty rubble at the waterline consisting of fine grained, quartz-rich rocks containing up to 10% disseminated pyrrhotite and trace chalcopyrite within garnetiferous amphibolites. The occurrence is approximately along strike from others previously reported (Gale and Eccles, 1988) and is interpreted as sulphide facies iron formation.

In addition, several occurrences of cummingtonite/anthophyllite, attributed to hydrothermal alteration, were also noted in Amisk Group volcanic rocks (Fig. GS-13-1).

From an exploration viewpoint, the most interesting result of this work is that the hosts of all known and new sulphide and cummingtonite/anthophyllite occurrences are now interpreted as Amisk volcanic and volcaniclastic rocks. In general, these occurrences have not received a great deal of attention subsequent to their discovery by early prospectors because they were thought to be hosted by likely unproductive arenaceous sedimentary rocks. Their re-interpretation as Amisk felsic volcanic rocks significantly increases their potential for economic mineralization and invites further attention from the exploration industry.

Patchy yellow uranophane alteration was noted by McRitchie (1985) in a number of large pink and white granitic pegmatite dykes (Fig. GS-13-1).

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GS-14 RICE LAKE GREENSTONE BELT MINERAL OCCURRENCE DOCUMENTATION: STATUS REPORT

by P. Theyer

Theyer, P. 1989: Rice Lake greenstone belt mineral occurrence documentation: status report; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The current inventory of mineral occurrences in the Rice Lake Greenstone Belt will be compiled and published as a series of reports and corresponding maps, each dealing with the area of an individual 1:50 000 NTS map sheet.

Field work in 1987, complemented by a few site inspections in 1988, completed the data collection phase of this program.

PRODUCTS

During this project, nine contributions to annual Reports of Field Activities and a Preliminary Map were published by the author, or senior geological assistants (Gaba, 1985; Schmidtke, 1984; Stewart, 1985; Theyer, 1983, 1984, 1985, 1987; Gaba and Theyer, 1984; Theyer and Gaba, 1986). These reports generally contain a tabular listing of the mineral occurrences investigated in that season, and other pertinent geological and geochemical data, or are devoted to detailed descriptions of one, or a few, mineral occurrences of special interest.

During this program a total of 228 mineral occurrences have been investigated, recorded, sampled and, in selected instances, geologically mapped in detail.

The scope of mineral occurrence investigations in the Wallace Lake area was expanded into a detailed study concentrating on the lithology, lithochemistry and the mineralization of the Gatlan gold deposit. This study was undertaken as an M.Sc. thesis (Gaba, 1987) under the joint supervision of the University of Western Ontario and the Manitoba Department of Energy and Mines.

Current work consists of field data collation and preparation for eventual publication. This work includes preparation of 7 geological compilation map sheets at a scale of 1:50 000, drafting of approximately 150 detailed geological sketch maps, and the preparation of an accompanying descriptive text.

Completed and ready for printing is the documentation of 52L/13 (Theyer and Yamada, 1989); in editorial review is the manuscript documenting 52L/14 (Theyer and Ferreira, in prep.); and mineral occurrence descriptions for 52M/3 are in preparation.

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GS-15 THOMPSON NICKEL BELT PROJECT - PIPE PIT MINE, SETTING AND OSPWAGAN LAKES

by J.J. Macek and W. Bleeker[1]

Macek, J.J. and Bleeker, W. 1989: Thompson nickel belt project - Pipe Pit Mine, Setting and Ospwagan Lakes; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

Geological investigations in the Thompson Nickel Belt (TNB) were conducted in the area between Setting Lake and Ospwagan Lake.

Field work at Pipe II Open Pit mine has been completed and a detailed lithostratigraphy of the Ospwagan group supracrustal rocks is presented. Laboratory evaluation is now in progress.

Exposures previously assigned to the Ospwagan group on Setting and Ospwagan Lakes were re-examined, new data collected and regional lithostratigraphic correlations made. Regional applicability of the lithostratigraphy established at Pipe II and Thompson Open Pit mines has been confirmed.

PIPE II OPEN PIT

Field work at Pipe II Open Pit Mine completed data collection for production of a final map.

Reconstructed lithostratigraphic section

Figure GS-15-1 shows detailed reconstruction of the Ospwagan group lithostratigraphy as exposed at Pipe II mine. Preparation of analogous diagrams for Ospwagan Lake, Manasan Quarry and Thompson Open Pit mine is in progress.

Intense polyphase deformation and transposition has modified the primary thickness of all layers. Nevertheless, in order to make comparisons throughout the region accurate measurements of layer thicknesses have been made wherever outcrops permitted. The range in measured thickness of each layer is shown in the lithostratigraphic column. The apparent inclination of layers in some parts of the diagram has no geological significance since it resulted from plotting varying thicknesses of layers.

Unit numbers (from Preliminary Maps 1985-1 to 8) are shown between the metric scale and the reconstructed lithostratigraphic column. Brief descriptions equate the lithologies with the graph of apparent magnetic susceptibilities.

Major oxides relating to the plotted layers are plotted farther to the right. Graphs show preliminary results; additional chemical analyses are in progress.

Magnetic susceptibilities were measured directly on outcrops at sample locations, using a GEOINDUSTRIES JH-8 susceptibility meter. In addition, within-unit variations were measured at several locations to ensure that values are representative. In composite units consisting of thin (1-5 cm), rhythmically repeating layers of extreme compositional variation (such as units 12a, c, d and 13), the susceptibility of each lithologic component was measured separately, and the average value derived by calculations which took into consideration the relative thickness of the components and their frequency of occurrence. The results are plotted as ranges of susceptibility values on logarithmic scale (Fig. GS-15-1). The height of the bars corresponds to the thickness of the layers as shown on the right hand side of the lithologic column (not necessarily the average thickness of the lithological layer). To simplify the graphs, Molson Dykes (metabasalt-metagabbro) have been omitted. Magnetic susceptibility of these dykes ranges from 100 to 400 SI units; most frequently encountered values range between 100 and 200 SI units.

The detailed lithostratigraphic section from Pipe II Mine site is unique to this locality, with respect to the large number of thin layers and their mineralogical and textural characteristics. More importantly, however, investigations at other localities (Thompson Open Pit Mine, Ospwagan Lakes, Manasan Quarry, Setting Lake) show that larger lithostratigraphic units can be correlated along most if not all of the TNB. Correlation of individual layer is less satisfactory.

This detailed information is, however, important for exploration purposes, since a limited length of drill hole intersection may be assigned to its proper stratigraphic position which should prove essential for exploration in TNB.

SETTING LAKE

Exposures of lithologic units that were in the central part of the Setting Lake previously assigned to the Ospwagan group (Albino and Macek, 1981) were re-examined. Observations are reported below with reference to Figure GS-15-2. The map on the figure shows the distribution of the islands (between the dotted and dashed lines) where rocks of the Ospwagan group were encountered. A schematic lithostratigraphic reconstruction was generated from these observations assuming that the relative position of the lithologic units is still largely preserved despite the influence of tectonism. Six major lithostratigraphic units were defined:

1. Quartzite-siliceous shale:

This unit consists of thin- to thick-layered impure quartzite interlayered with thin beds or laminae of dark grey siliceous shale (Fig. GS-15-3). Volumetric ratios between the quartzite and shale typically vary from 30:1 to 5:1.

2. Ferruginous metasiltstone-shale:

Laminated- to thinly-layered, fine grained ferruginous metasiltstone-shale with alternating silica poor and silica rich laminae or thin layers (Fig. GS-15-4) characterize this unit. It is widespread and is one of the characteristic lithologies on which the Ospwagan group was originally established (Scoates *et al.*, 1977).

3. Metamorphosed sandstone - pebbly metaconglomerate:

It conformably overlies the ferruginous metasiltstone-shale and was previously described as graded grits (Albino and Macek, 1981). Metasandstone-pebbly metaconglomerate consist of numerous well-graded beds (0.2 to 1.5 m thick) of metaconglomerate-metasandstone-metasiltstone-shale (Fig. GS- 15-5). Graded beds occur more frequently at the bottom of the unit. The unit grades up section into massive metasandstone and metasiltstone with rare shale. Matrix-supported pebbly metaconglomerate beds contain clasts of black quartz with greasy luster and light grey felsic lithic fragments (Fig. GS- 15-6) that are subangular to suboval and up to 5 cm in diameter. The grey weathering matrix of the metaconglomerate is biotite rich metasandstone or metasiltstone.

4. Cummingtonite-cordierite rock:

Albino and Macek (1981) reported a light grey to beige weathering, several meter thick sequence of layers (2 to 20 cm thick) that appear to be composed almost entirely of foliated rosettes or fan-like aggregates of anthophyllite- cordierite. Examination by universal stage revealed the monoclinic symmetry of the amphibole. Further follow-up by E. Froese of GSC established that the amphibole is cummingtonite (Table GS-15-1). This Mg rich unit is mineralogically and chemically unusual and deserves further investigation.

5. Metagreywacke:

Yellowish beige weathering metagreywacke conformably overlies the cummingtonite-cordierite unit. Metagreywacke is commonly highly strained and mylonitized, and is generally devoid of primary sedimentary structures. A few outcrops show poorly sorted, poorly defined matrix-supported conglomerate beds. Clasts are subangular and have a felsic composition (Fig. GS- 15-7).

Preliminary thin section examination shows that the biotite rich, fine grained quartz-feldspathic matrix supports distinct grains of quartz, plagioclase, microcline and lithic clasts. Clast types include: 1) quartz aggregates; 2) equigranular leucogranite; and 3) nonequigranular felsic lithic clasts with distinctly larger microcline, plagioclase or quartz in a much finer matrix.

[1]University of New Brunswick

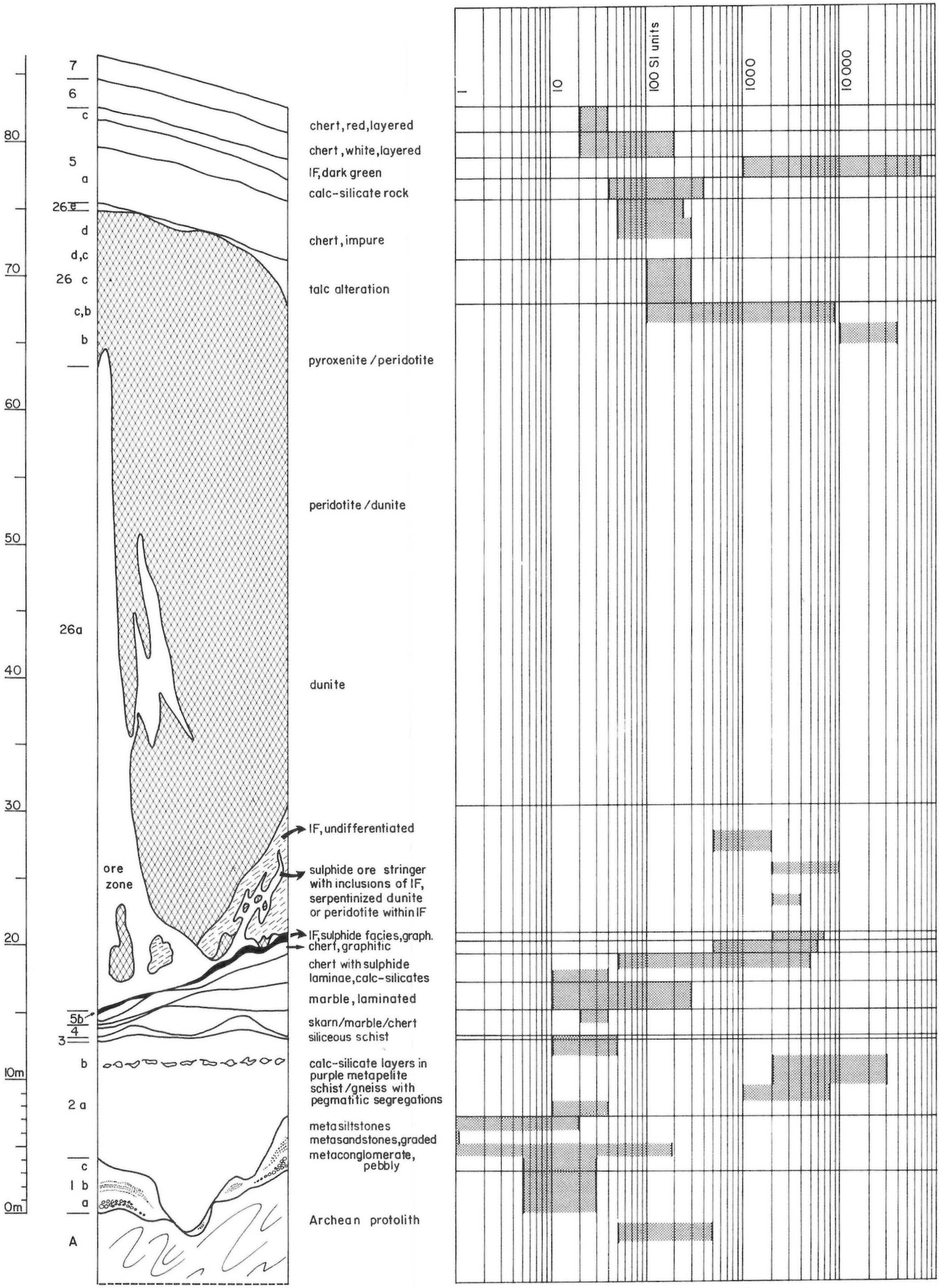

Figure GS-15-1: Ospwagan Group lithostratigraphy as intersected at Pipe II open pit mine site. For explanation see text.

Figure GS-15-1: Ospwagan Group lithostratigraphy as intersected at Pipe II open pit mine site. For explanation see text.

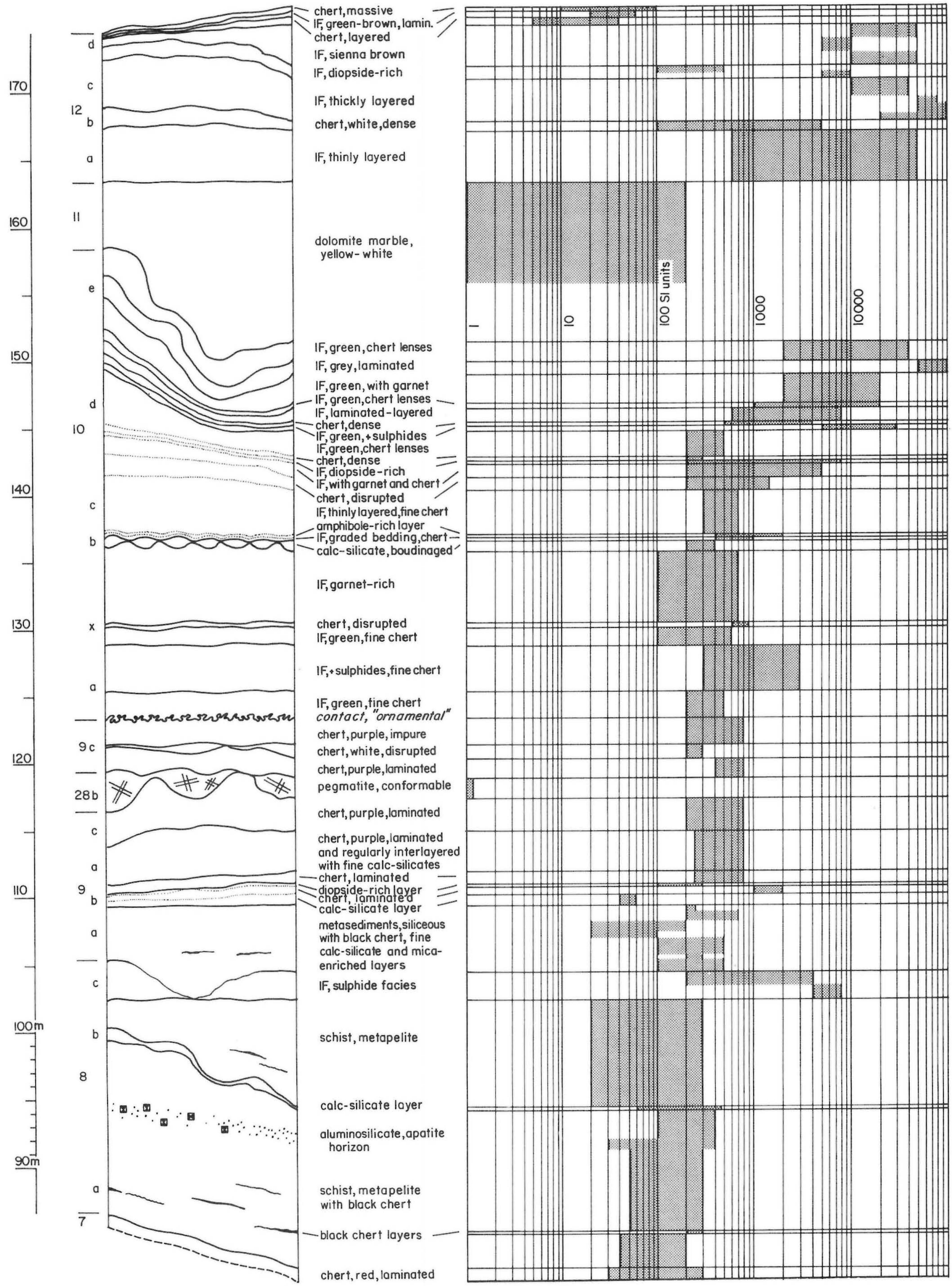

Figure GS-15-1: *Ospwagan Group lithostratigraphy as intersected at Pipe II open pit mine site. For explanation see text.*

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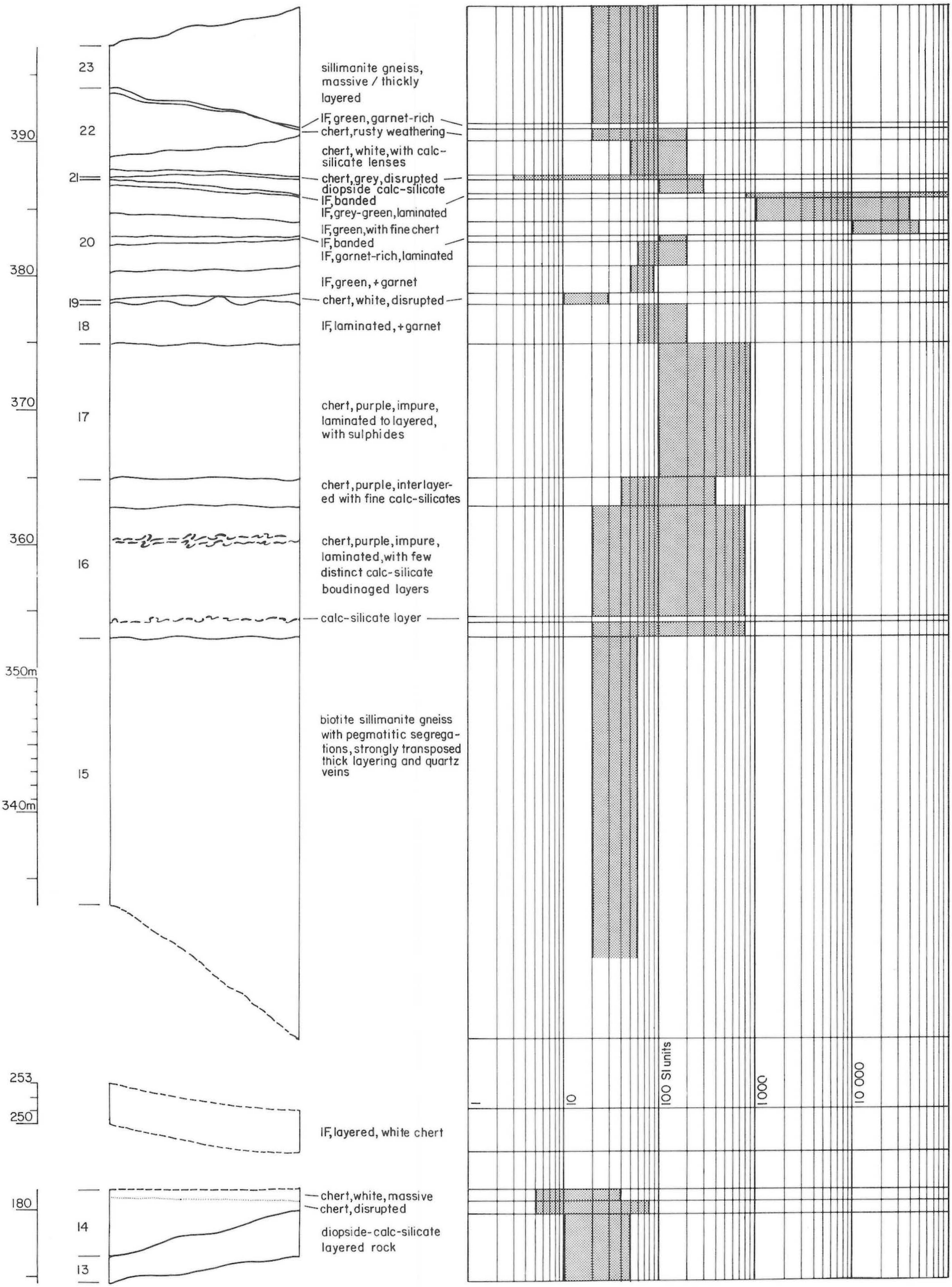

Figure GS-15-1: Ospwagan Group lithostratigraphy as intersected at Pipe II open pit mine site. For explanation see text.

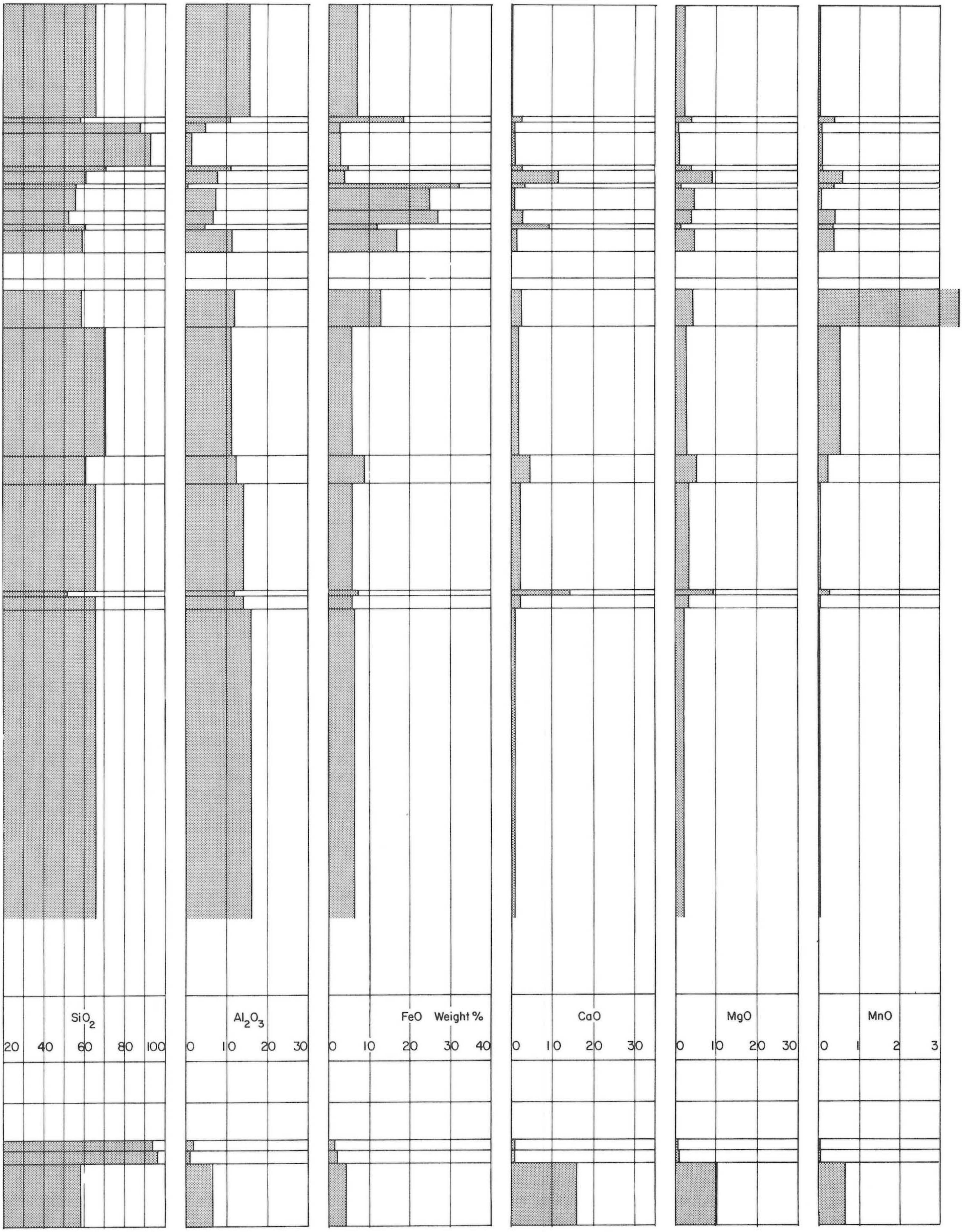

Figure GS-15-1: Ospwagan Group lithostratigraphy as intersected at Pipe II open pit mine site. For explanation see text.

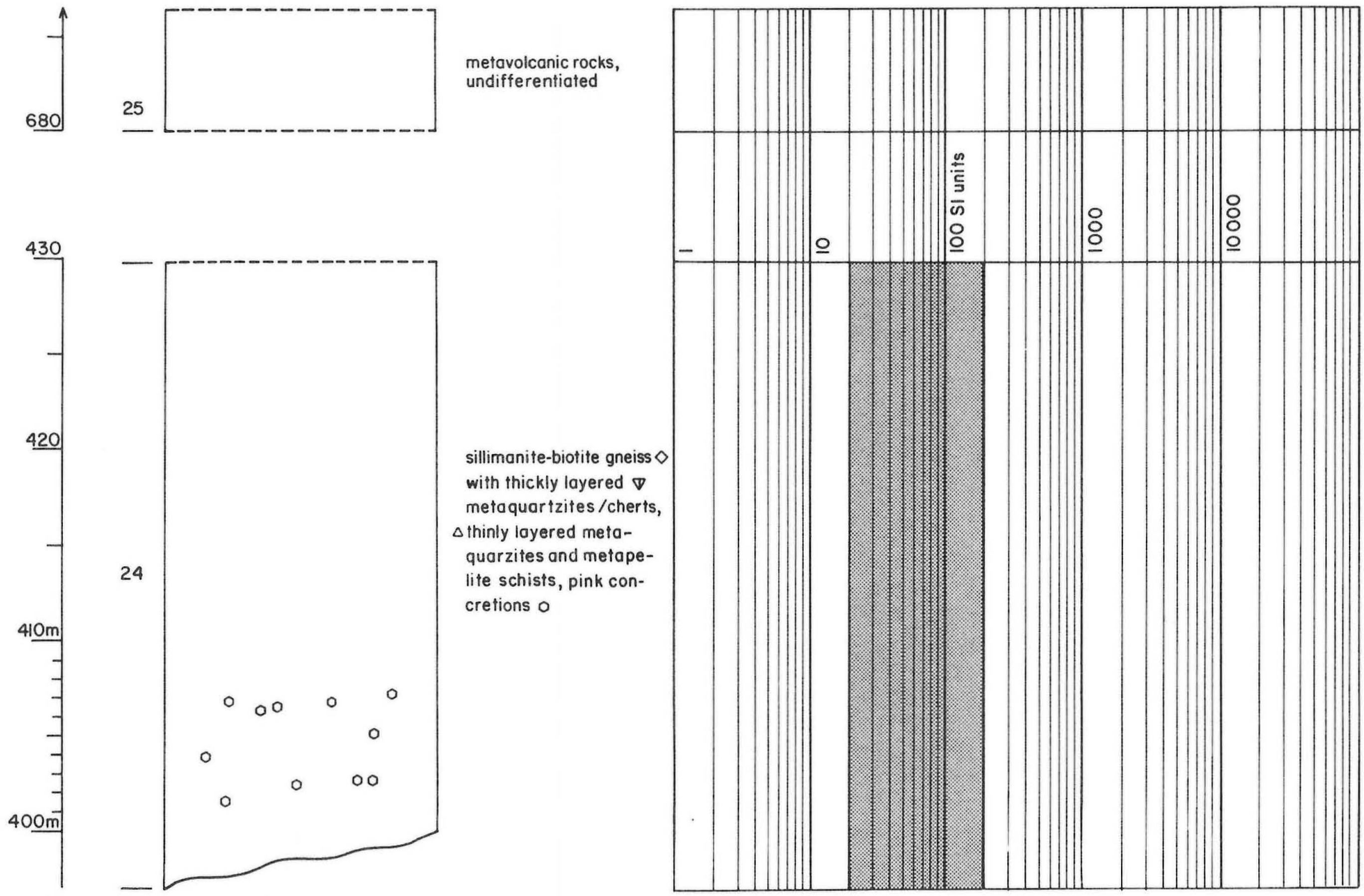

Figure GS-15-1: *Ospwagan Group lithostratigraphy as intersected at Pipe II open pit mine site. For explanation see text.*

TABLE GS-15-1
MICROPROBE ANALYSES OF MAJOR MINERALS CONSTITUTING THE CUMMINGTONITE-CORDIERITE ROCK ON SETTING LAKE

	Biotite	Cummingtonite	Cordierite
SiO_2	39.33	55.58	48.42
TiO_2	1.31	0.03	-
Al_2O_3	16.73	1.63	34.91
FeO	9.63	18.36	3.57
MnO	-	0.32	0.06
MgO	18.39	21.82	11.23
CaO	-	0.33	-
Na_2O	0.87	0.39	0.62
K_2O	8.33	-	-
Total	94.93	98.46	98.81

Analyst: M. Bonardi, Mineralogy Section, Geological Survey of Canada

6. Metavolcanic and related rocks:

This heterolithologic unit consists of basaltic pillowed and massive flows and medium- to coarse-grained homogeneous bodies of metagabbro. Metagabbro is: 1) directly associated with metavolcanic rocks; 2) encountered in association with metasedimentary rocks; or 3) is exposed as isolated islands in the central part of Setting Lake. These metagabbros probably represent hypabyssal sills coeval with the metavolcanic rocks.

The affinity of these rocks was previously unknown (Albino and Macek, 1981) because they could not be distinguished from Kisseynew amphibolites that underlie the Sickle group. This summer, several metadiabase dykes of the Molson Dyke Swarm were found to cross-cut these amphibolites (Fig. GS-15-8). Some Molson dykes exposed in metasediments (which in turn are in direct contact with metagabbros) display preserved chilled margins (Fig. GS-15-9). Molson dykes are unknown from the Churchill Province, thus it is concluded that metabasalts and metagabbros in the central part of Setting Lake belong to the Ospwagan group.

Plagioclase-phyric dykes

Plagioclase-phyric dykes reported from outcrops at Wabowden boat launch (Albino and Macek, 1981) and Pipe Pit Mine (Bleeker and Macek, 1988 T-1) were also found to intrude ferruginous metasiltstone-shale and metasandstone-pebbly metaconglomerate in the central part of Setting Lake. Despite the uncommon porphyritic texture, all other features are analogous to those observed in Molson dykes. Their mutual parallelism and close association, suggest that the plagioclase-phyric dykes are part of the Molson Dyke Swarm. Similar plagioclase-phyric dykes were observed within reworked basement gneisses at Manibridge and Thompson mines.

OSPWAGAN LAKE

Geological investigations focused on three objectives:

1. Correlation of metasedimentary units with the lithostratigraphy established by Bleeker and Macek (1988).
2. Collection of field data and samples for detailed analysis comparable to that done for data and samples collected from Thompson mine, Pipe II open pit site and Manasan quarry.
3. Further correlation of the improved lithostratigraphic section at Ospwagan Lake with those for other areas of the TNB.

Many new outcrops were examined due to exceptionally low water levels. The geological highlights are summarized in Figure GS-15-10 (figure out of numerical sequence in position in text) and reported below:

1. The location of the contact between migmatites (reworked Archean protolith) and Ospwagan group has been revised (compare to that shown by Macek and Russell (1978)). The major change is in the northeast part of Lower Ospwagan Lake where the contact is close to the shoreline.
2. New indicators of inferred overall younging of the Ospwagan group have been added to those previously reported by Bleeker and Macek (1988) and will help to further refine the regional structure.

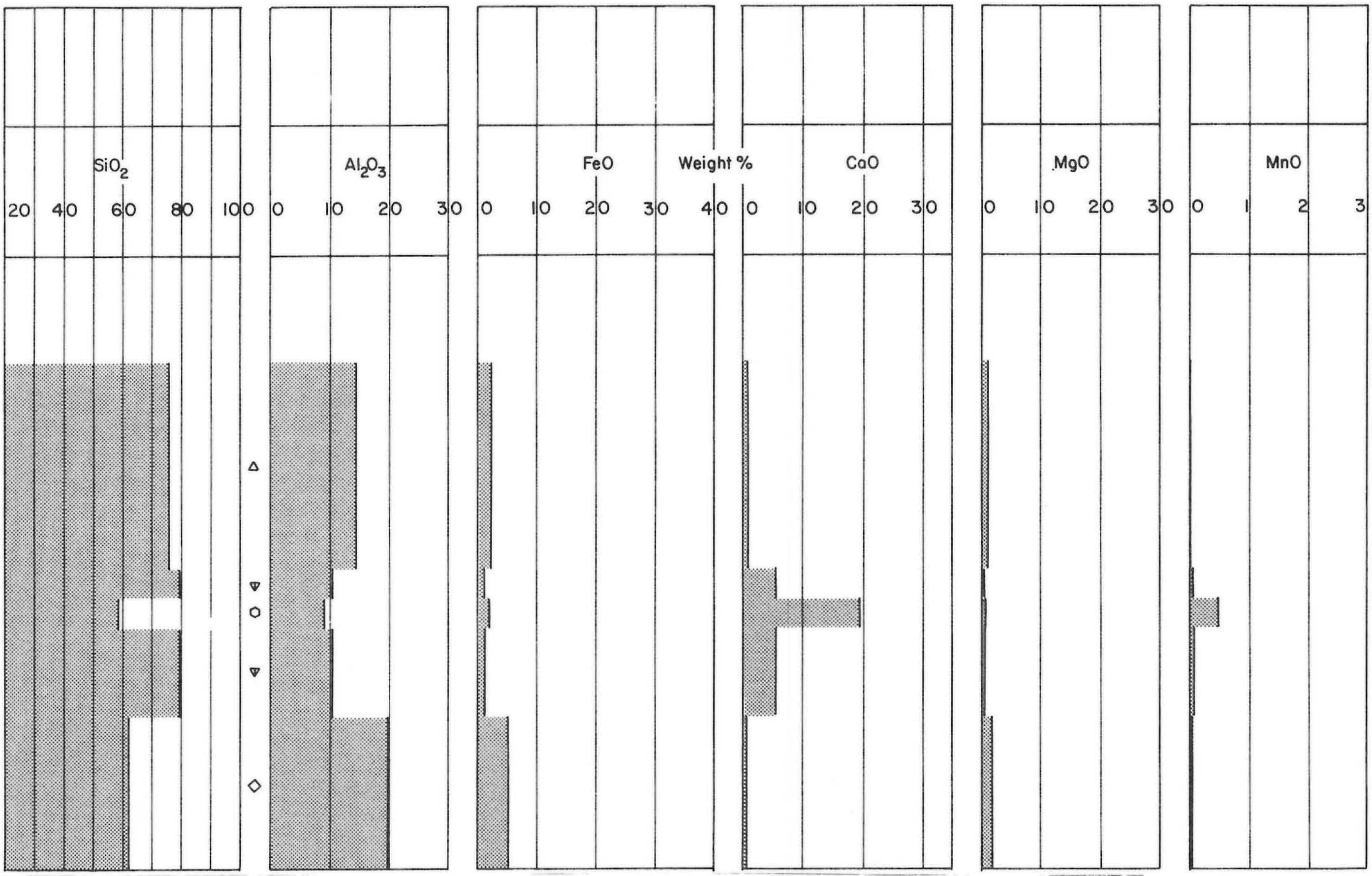

Figure GS-15-1: Ospwagan Group lithostratigraphy as intersected at Pipe II open pit mine site. For explanation see text.

3. Metasiltstone-shale, metasandstone-pebbly metaconglomerate, metagreywacke, and rhyolite on Ospwagan Lake and Setting Lake form an upper portion of the Ospwagan group. This correlation is based on the following observations:
   a) Layered quartzite-metasiltstone, on the largest island in the central part of Lower Ospwagan Lake (Fig. GS-15-11), are similar to the metasandstones-pebbly metaconglomerates at Setting Lake, but graded bedding is not as well developed (see inset of Fig. GS-15-11);
   b) Metagreywacke with felsic lithic fragments (Fig. GS-15-12) are similar to the metagreywackes described from Setting Lake;
   c) Metasandstone-metasiltstone and metagreywacke on Ospwagan Lake are closely associated with metaquartzite-metapelite schists that are similar to the metaquartzites-siliceous shales on Setting Lake. They are also similar to the parts of "footwall" and/or "core quartzites" of the Thompson Open Pit mine; and
   d) A rhyolite, (first recognized by W. Bleeker in 1988) that is in close proximity to mafic metavolcanic rocks, is interlayered with metagreywacke and metasandstone or metasiltstone similar to those encountered on the central island of Lower Ospwagan Lake. The locations of the discussed sediments are shown by a stippled pattern in Figure GS-15-10.
4. Several reefs of metaperidotite that were temporarily exposed, show a well preserved igneous texture (Fig. GS-15-13). In another outcrop a minor Molson dyke that intrudes metaperidotite (Fig. GS-15-14) has been sampled.

CONCLUSIONS

The re-examination of the Ospwagan group conducted on Setting Lake and Ospwagan Lake confirmed the regional applicability of the reconstructed lithostratigraphy as presented by Bleeker and Macek (1988). It also resulted in new data and observations that have further implications for the understanding of the geology of the TNB. The evaluation of this data is in progress.

ACKNOWLEDGEMENTS

The authors wish to thank Inco Ltd. for the access to its properties, generous logistical support to the second author, and the use of their magnetic susceptibility meter during the summer. Falconbridge Ltd. provided access to its property and permitted sampling of drill core for further studies. The Geological Survey of Canada is acknowledged for microprobe analyses and permission to publish the results.

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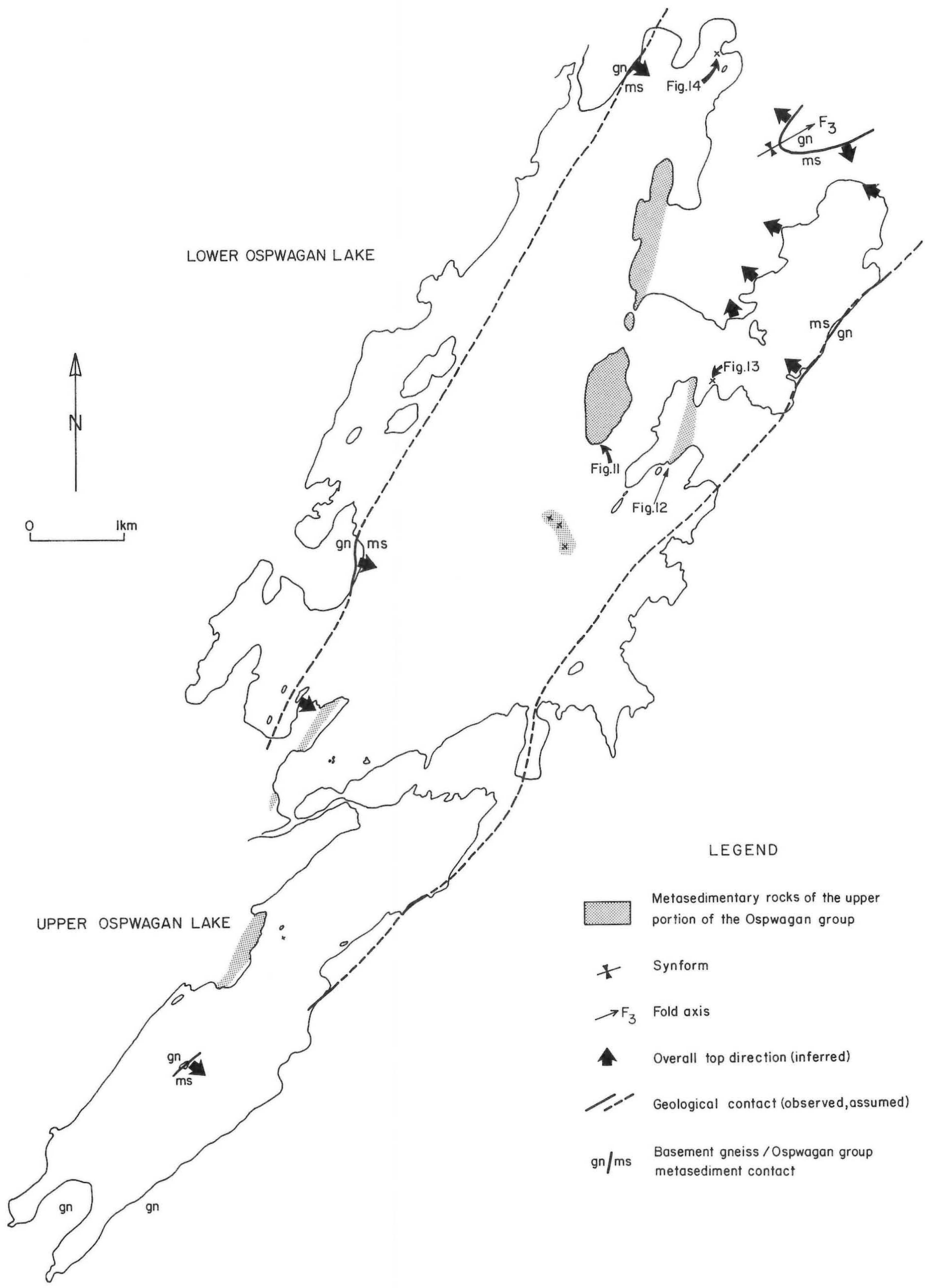

Figure GS-15-2: Ospwagan Group lithostratigraphy as observed on Setting Lake. For details see text.

Figure GS-15-3: Metaquartzites-siliceous shales, Setting Lake.

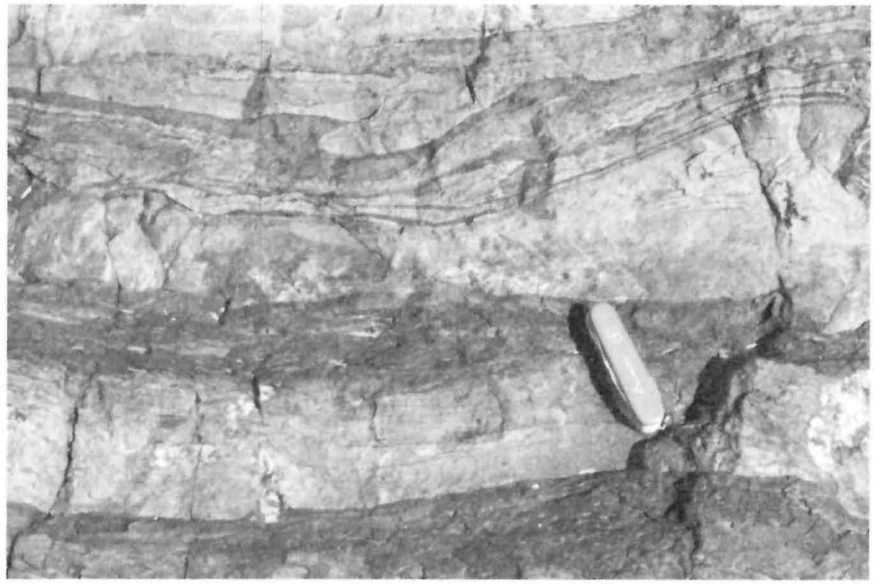

Figure GS-15-4: Ferruginous metasiltstones-shales, Setting Lake.

Figure GS-15-5: Metasandstone-pebbly metaconglomerate, (note scour), Setting Lake.

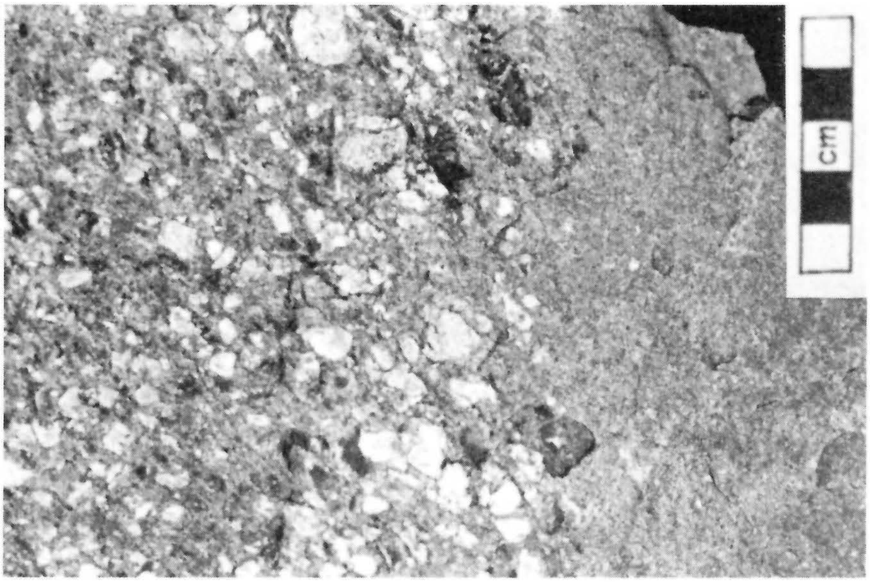

Figure GS-15-6: *Graded metaconglomerate, Setting Lake.*

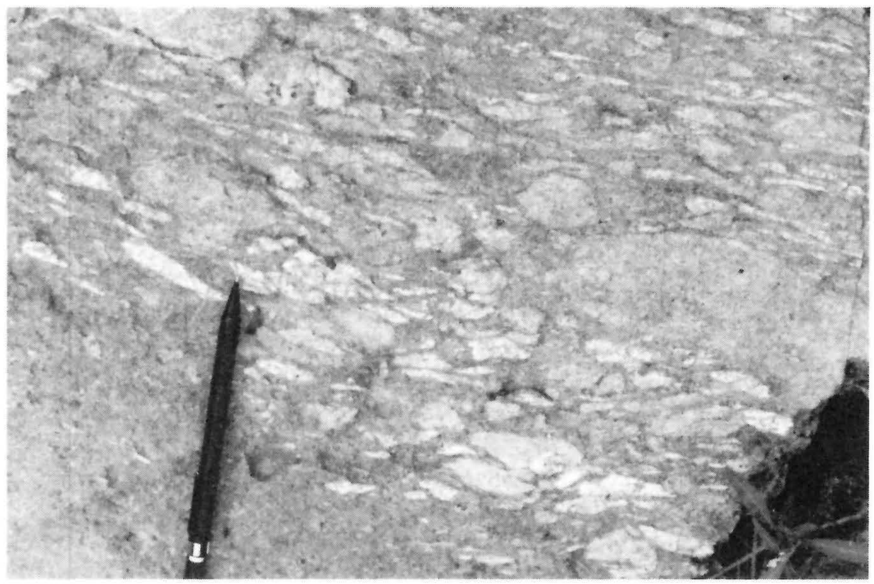

Figure GS-15-7: *Metagreywacke with felsic lithic fragmental layers, Setting Lake.*

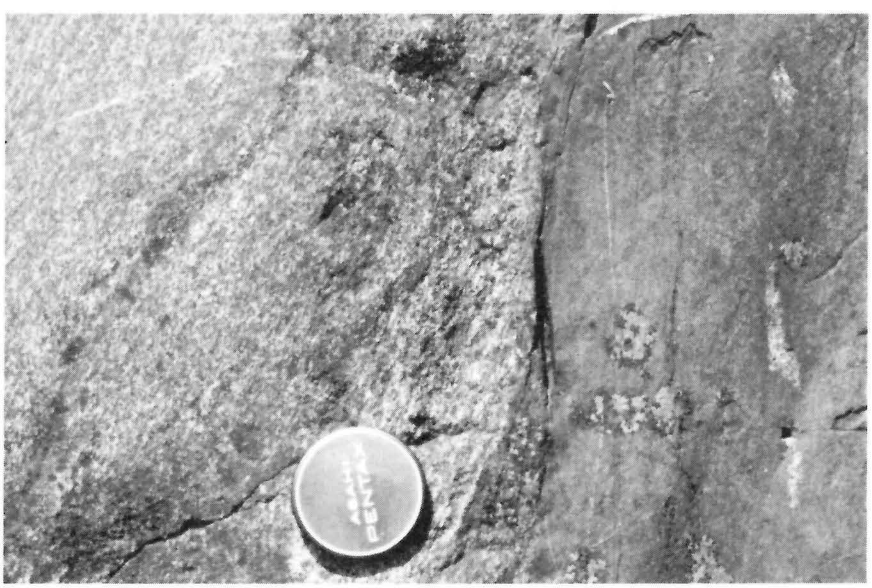

Figure GS-15-8: *Molson Dyke (at right) cross-cutting amphibolite of metagabbro ?, Setting Lake.*

Figure GS-15-9: *Preserved chilled margin in Molson Dyke, Setting Lake.*

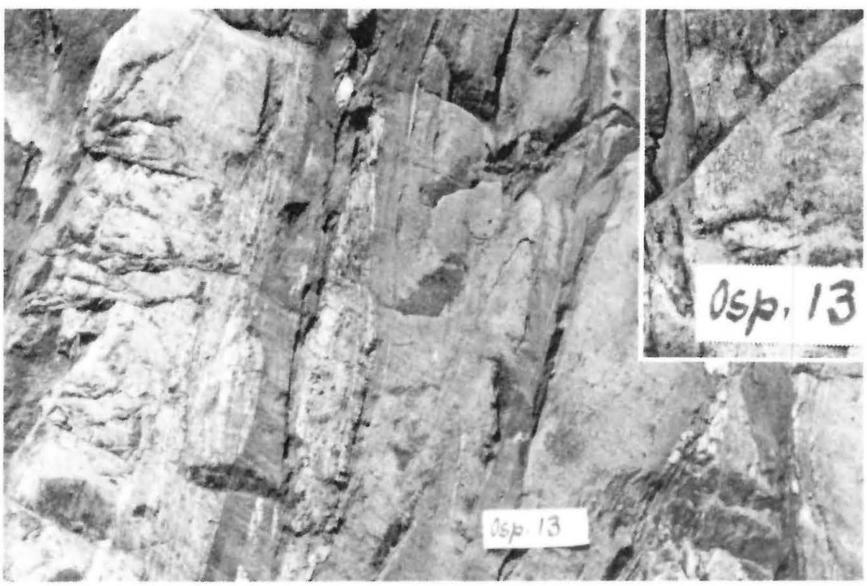

Figure GS-15-11: *Layered metasandstone-metasiltstone, Lower Ospwagan Lake, central island. inset; pebble metaconglomerate.*

Figure GS-15-12: *Metagraywacke with felsic lithic fragments.*

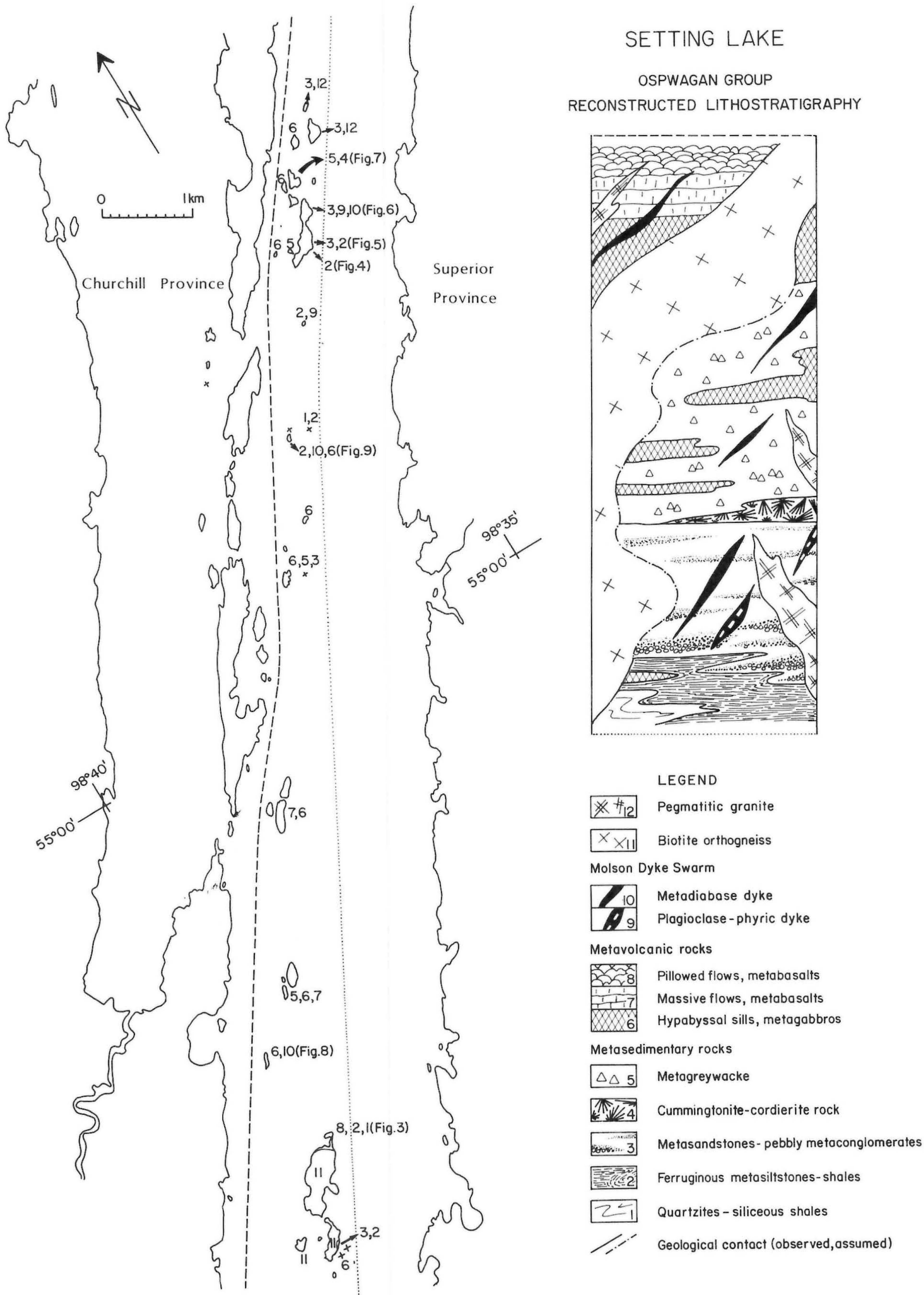

Figure GS-15-10: Ospwagan Lake geological highlights. For details see text.

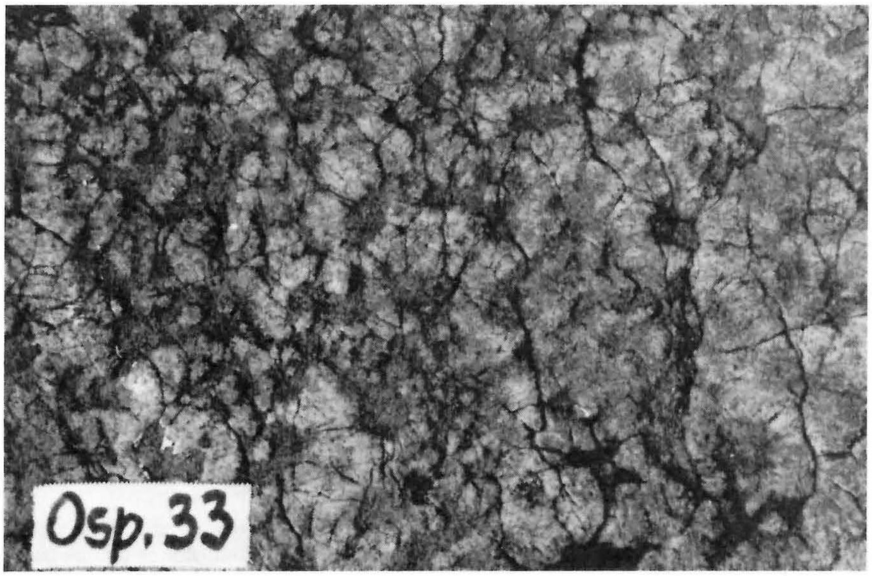

Figure GS-15-13: Texture of undeformed peridotite, Lower Ospwagan Lake.

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Figure GS-15-14: Molson Dyke intruding sheared peridotite, Lower Ospwagan Lake.

GS-16 CROSS LAKE SUPRACRUSTAL GEOLOGICAL INVESTIGATIONS

by M.T. Corkery and P. G. Lenton

Corkery, M.T. and Lenton, P.G. 1989: Cross Lake Supracrustal geological investigations; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

During 1989 the Cross Lake mapping program focused on laboratory studies, with a minor field component to solve problems in interpretation based on new data presented in the following reports. Internal reports were submitted by D. Davis (Royal Ontario Museum) on geochronological studies and M. Breedveld (The Free University, Amsterdam) on thermo- tectonic aspects of the supracrustal belt .

Davis provided several new U/Pb age determinations (Corkery *et al.*, in prep) for intrusive units within the Molson Lake Domain on the south flank of the supracrustal belt. Three populations of zircon from the Clearwater Bay tonalite produce concordant data points with widely differing ages. The probable age of crystallization is 2839 ± 3Ma. Two younger zircon populations at 2695 ± 2 Ma and 2760 Ma. are interpreted to indicate zircon growth during major periods of metamorphism (Corkery *et al.*, in prep). Zircon populations from tonalite of the Whiskey Jack Complex produced three concordant data points that range in age from 2710 ± 3 Ma to 2734 ± Ma. The age of crystallization is interpreted to be 2734 ± 3 Ma.

Breedveld undertook a thermo-tectonic pilot study of the supracrustal belt during a three month field program in 1988. He describes two major periods of deformation postdating deposition of the Cross Lake Group, but he found no evidence of earlier deformational events (Breedveld, 1989). The earliest event (D_1) he interprets as Kenoran, at about 2550 Ma; and the second (D_2), a more protracted event, is tentatively regarded to be Hudsonian. Metamorphic events (M_1 and M_2) are approximately coincident with the periods of deformation.

Breedveld (1989) reports that "the sequence of fabrics and folds indicate two major episodes of deformation: D_1 and D_2. Both are progressive deformations and clearly separated from each other. This is based on style of the structures, their orientation and sense of movement, orientation of the stress field, time of occurrence and prevailing metamorphic conditions. Structural-metamorphic data indicate that D_1 was related to prograde metamorphism, and that D_2 was related with retrograde metamorphism." The metamorphism interpreted as M_1 in the supracrustal belt increases from upper low grade in the east to high grade in the west. Metamorphic evolution is best demonstrated by the Cross Lake Group metasediments. Three reaction-isograds generated during D_1 were determined. They are, from east to west: "staurolite in", "sillimanite II in" and "orthopyroxene in".

Breedveld (1989) concludes that "D_1 was related with prograde metamorphism. The geothermal gradient was steep, and is estimated at 40°-50°C/km . Peak metamorphic conditions for central Cross Lake are estimated at 600-675C, 3-4 kb and $pH_2O << 1$. The period between D_1 and D_2 is characterized in central Cross Lake by the start of [retrogression] of sillimanite II to muscovite + quartz symplectites. The retrograde metamorphism was continued during D_2. Prograde metamorphism during D_2 is not demonstrated. The time interval between $D_1$and D_2 is however so large that the possibility that D_2 was related with a prograde as well as a retrograde metamorphism is not excluded. Peak metamorphic conditions during D_2 for central Cross Lake are estimated at 500°-600°C, 2- 3 kb and 0.5 $pH_2O << 1$."

The information from these studies and field proofing by the authors provides a basis for more detailed subdivision of the supracrustal rocks, and a reevaluation of the order of events in the Cross Lake region (Table GS-16-1 and Fig. GS-16-1). The most significant additions are:

1. recognition of 2839 Ma granitic intrusive rocks in the Molson Lake Domain,
2. identification of supracrustal rocks (Teacher Group), occurring as inclusions within the Molson Lake Domain tonalite (2839 Ma), that are older than any supracrustal units within the Cross Lake belt,
3. subdivision of the Cross Lake Group into two groups: the Gunpoint Group, with felsic pyroclastic rocks (U/Pb zircon age 2730 Ma), and unconformably overlying Cross Lake Group, (detrital zircons as young as 2709 Ma).

Table GS-16-1
ORDER OF GEOLOGICAL EVENTS (CROSS LAKE AREA)

Younger Cratonic Associations

16) Late brittle deformation manifested by fault breccia, pseudotachylite and erratic foliation developed in some Molson dykes
15) Intrusion of Molson dyke swarm; most abundant in the major NE shear zones. (1884 Ma)[4]
14) Periodic reactivation of shear zones accompanied by minor folding
13) D_4-M_4 main Kenoran orogenic event: intrusion of granite plugs (2653 Ma)[1] and pegmatites (largely controlled by the major shear zones) during the waning stages.(2658 - 2637 Ma)[2]
12) Intrusion of small gabbro dykes and plugs.

Intrusive contact

11) Initiation of high potassium basalt volcanism contemporaneous with fluvial to marine sedimentation.
10) Deposition of Cross Lake group alluvial and fluvial conglomerate and sandstone.

Unconformity

9) D_3-M_3 regional metamorphism and deformation, granite plutonism (2719 Ma)[1] and folding concomitant with activation of major linear shear zones. Spans the period of deposition of Cross Lake Group. (2713 - 2695 Ma)[2]
8) Intrusion of hornblende porphyritic gabbro dykes.

Intrusive contact

7) D_2-M_2 deformation and metamorphism: produced northeast trending migmatites that overprinted east-west D_1 foliation. Contemporaneous with, to post deposition of, Gunpoint Group. (circa 2738 Ma)[3]
6) Deposition of the predominantly continental Gunpoint Group: fragmental rhyodacite and alluvial, fluvial and marine sediments, synchronous with D_2- M_2.(2730 Ma)[1]

Unconformity

5) Pipestone Lake group incorporated into a cratonic landmass during a period of cratonization concomitant with Whiskey Jack Complex intrusions (2734 Ma)[1]

Oceanic Association

4) Deposition of Pipestone Lake Group basalts and subordinate sediments. Intrusion of anorthosite-gabbro complex with deposition of associated feldspar porphyritic basalts. (2760 Ma)[1]

Old Cratonic Masses

3) D_1-M_1 deformation and metamorphism: produced strong foliation (currently east-west) in Clearwater Bay Complex.
2) Formation of presupracrustal belt cratonic masses of Molson Lake Domain (includes Teacher Group) and Pikwitonei Domain on the south and north flanks of the supracrustal belt. (2839 Ma)[1]
1) Early supracrustal sequence - Teacher Group - metabasalt, metagabbro and metasediments

[1]Corkery *et al.*, in prep
[2]Krogh *et al.*, 1985
[3]Mezger *et al.*, in press
[4]Heaman *et al.*, 1986

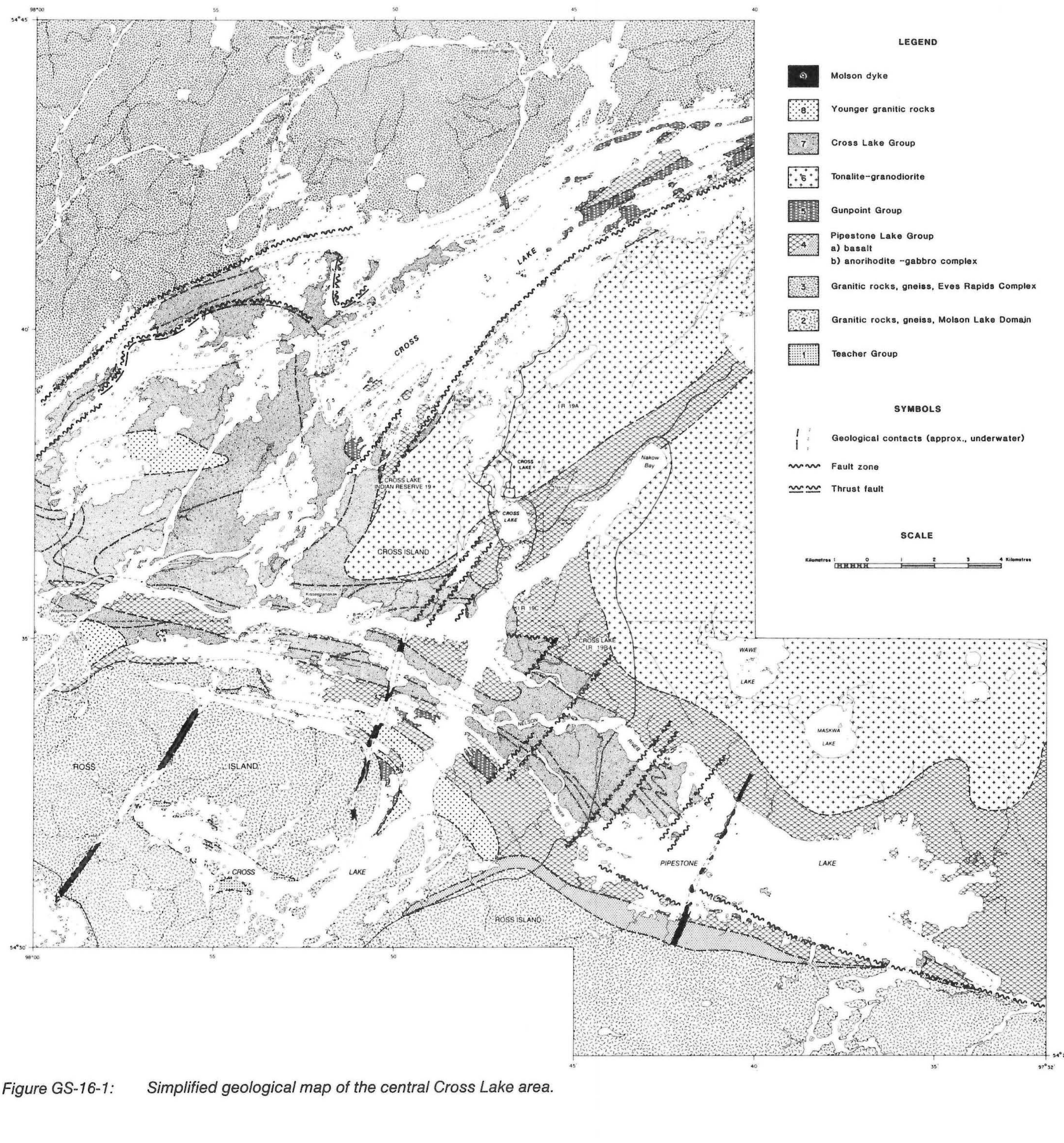

Figure GS-16-1: *Simplified geological map of the central Cross Lake area.*

Two distinct metamorphic events that reached granulite grade are interpreted from an extensive geochronological program in the Pikwitonei Domain (Krogh *et al.*, 1985). They indicate that "the older event ranged from 2713 to 2695 Ma - and possibly down to 2684 Ma - and the younger event ranged from 2658 to 2637 Ma". Similarly, Mezger *et al.* (1989) describe three periods of metamorphism; various calibrated geothermometers and geobarometers, and age information determined by U/Pb techniques on igneous and metamorphic zircon, garnet, sphene and rutile, were used to define the events. The earliest event "lasted at least from ca. 2744 Ma to ca. 2738 Ma" (Mezger *et al.*, 1989.). Two younger events agree with those defined by Krogh et al. (1985). U-Pb ages and Nd-isotopes, however, indicate that parts of the crust in the northwest Superior Province may be 3200 Ma or older, and Mezger *et al.* (1989) suggest that the three periods of metamorphism described in their study were superimposed on a continental crust that was in major part assembled before that time.

Breedveld's (1989) documentation of two major thermo-tectonic episodes is here interpreted, by the current authors, to represent the major Kenoran events; his interpretation of timing is however questioned. We consider that Breedveld's M_1 corresponds to the 2713 - 2695 Ma event and M_2 to the 2658 - 2637 Ma event described above and as M_3 and M_4 in table GS-16-1. Breedveld's proposed timing of thermo-tectonic events cannot be reconciled with the number and duration of events indicated by mapping nor the U-Pb geochronology in the belt.

In another component of the Cross Lake project a layered ultramafic on Pipestone Lake was drilled (diamond drill hole M-6-89, location UTM N 6 042 560 E 582 860) to delineate the thickness of the body and to test for possible chromitite layers. Previously analyzed grab samples of dunite with disseminated chromite contained chrome values reported as high as 6720 ppm. Disseminated chromite in the newly acquired drill core was most abundant near the top of the hole and decreased down section. No chromitite layers were found.

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GS-17 GEOLOGY OF THE NELSON RIVER, EAST CHANNEL (PART OF NTS AREA 63I/5)

by H.D.M. Cameron

Cameron, H.D.M. 1989: Geology of the Nelson River, East Channel, (Part of NTS area 63I/5); in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The shoreline of the east channel of the Nelson River, between High Hill Falls and Sugar Falls, was mapped at a scale of 1:50 000 as part of the Cross Lake mapping program (Corkery, 1983, 1985, 1986; Corkery and Lenton, 1984; Corkery and Cameron, 1987; Lenton and Anderson, 1983; Lenton *et al.*, 1986a, 1986b). This completes the mapping in NTS 63I/5.

Weber and Chase (1980) and Weber and Schledewitz (1979, 1980) mapped the southern part of the Nelson east channel, from Norway House to the confluence of the Echimamish River, at a scale of 1:100 000 as part of the Molson-Kalliecahoolie Project. The area had been mapped at a reconnaissance scale of 1:250 000 by Horwood (1934) and Bell (1962, 1978).

GEOLOGIC SETTING

The east channel of the Nelson River, south of the Pipestone Lake anorthosite complex (Cameron 1984, 1985, 1987) and the Cross Lake greenstone belt is underlain by a granitic gneiss complex of the Molson Lake domain. The northern margin of the gneiss has been deformed by a 1.5 km wide zone of strong ductile shearing occurring parallel to the contact between the gneiss complex and the anorthosite complex.

Mapping on the northern section of the east channel, below High Hill Falls in 1985/ 86/ 87, identified multi-component schlieric gneiss as the dominant rock type in the area. This gneiss comprises several phases of tonalite, diorite and amphibolite rafted in, and injected by, granodiorite and granite. Up to six phases may occur in a given exposure. Contacts between the major phases of gneissic and megacrystic granodiorite and granite are gradational.

In the northern part of the current map area the gneiss is dominantly megacrystic granodiorite with rafts of quartz diorite. The quartz diorite in turn contains xenoliths of diorite, gabbro and basalt-derived amphibolite. The units are injected by fine grained granodiorite and tonalite, coarse grained granite, alaskite and pegmatite.

Farther south, the quartz diorite becomes more prevalent and is injected by dykes and sills of coarse grained pink granite. The granite forms mappable bodies in the east- central and southern parts of the area (Fig. GS-17-1).

Shearing parallel to the direction of the river channels is common. The strongest set of ductile shears strikes 030°. Northeast trending bands of chloritic schist up to 6 m wide occur in the central part of the area. Late pseudotachylite faults trend from 296° to 234°.

PHASE DESCRIPTIONS

Relative ages and field relations of the supracrustal and intrusive phases are shown in Table GS-17-1.

I. Main Phases:

MEGACRYSTIC GRANODIORITE

Medium- to coarse-grained, foliated to gneissic granodiorite is white to buff pink weathering and contains 2 mm to 3 cm potassium feldspar megacrysts. The granodiorite contains agmatized, nebulitic, light grey, medium grained tonalite inclusions and angular xenoliths of medium grey diorite or gabbro. Schlieren and amphibolite xenoliths also occur. Pegmatite and aplite veins, to 1 m and veins of fine grained granodiorite intrude the granodiorite.

RED MEGACRYSTIC GNEISSIC BIOTITE GRANITE

Coarse grained to megacrystic granite has a matrix grain size of 1-8 mm and contains 2 to 3 cm augened potassium feldspar megacrysts. The rock is foliated to gneissic and has 2-10 cm *lit par lit* layering. The weathered surface is pink with red hematite staining. Nebulitic layers of grey, biotite rich megacrystic granodiorite are common.

The granite contains a wide variety of agmatized inclusions. These include fine grained amphibolite, tonalite and schlieric layers in zones to 1 m wide. Angular, agmatized 3 to 40 cm xenoliths of fine- to coarse-grained meso- to melanocratic diorite or gabbro form zones to 4 m wide. Some inclusions of coarse, pitted leucogabbro also occur.

The granite is cut by veins and dykes of pegmatite, aplite, fine- to medium- grained granodiorite to tonalite and dykes of Molson diabase to 3 m.

GNEISSIC GRANODIORITE

Gneissic granodiorite is medium- to coarse-grained, with some feldspar megacrysts to 1.5 cm. The weathered surface is light- to medium-grey to pink with 4 mm 30 cm *lit par lit* layering. Agmatized amphibolite inclusions form zones up to 3 m thick and characteristically appear as weathered out pits on the outcrop surface. Some mafic inclusions show internal layering that appears to be remnants of pillow selvedges. The rock also contains inclusions of medium grey, fine- to medium- grained tonalite, and schlieren.

Pegmatite, aplitic granite and veins of the fine grained tonalite to granodiorite intrude the granodiorite.

BIOTITE GRANITE

Coarse grained, foliated, pink leucogranite, common in the south central and southern parts of the map area, is one of the youngest intrusive phases. The granite contains 2 to 8 mm potassium feldspar crystals that locally range up to 2 cm. Granite sills, 6 m wide and larger, intrude and raft quartz diorite north of Sugar Falls.

II. Inclusions

Inclusions in the granite and granodiorite have a wide range of composition, but are dominantly mafic in composition.

METASANDSTONE

Metasandstone occurs as rare quartz-rich inclusions, agmatized to schlieric, and ranging in size from 2 to 15 cm by 30 cm to 2 m in megacrystic granodiorite. The rock is fine grained, light grey, homogeneous and equigranular.

AMPHIBOLITE

Amphibolite is fine grained and ranges from massive and homogeneous to compositionally layered. Some is derived from pillow basalts. It occurs as rounded to angular, agmatized inclusions and discontinuous layers to 3 m in megacrystic granodiorite and granite. The inclusions range in size from 5 cm to 3 m and commonly occur in zones to 10 m wide.

GABBRO

Melagabbro occurs as angular inclusions up to 2 by 3 metres, and as zones to 5 metres wide of smaller inclusions in fine- to medium-grained tonalite to granodiorite. At one location a raft of melagabbro, approximately 150 m wide, occurs in megacrystic gneissic granodiorite. The gabbro is medium- to coarse-grained, contains disseminated pyrite and resembles the melagabbro in the Pipestone Lake intrusive complex.

Leucogabbro is coarse grained, white weathering and has a pitted weathered surface. It occurs as elongate xenoliths in megacrystic gneissic granodiorite.

DIORITE

Diorite occurs as 3 to 30 cm inclusions in megacrystic granite and quartz diorite. It is fine grained, light- to medium-grey weathering with a

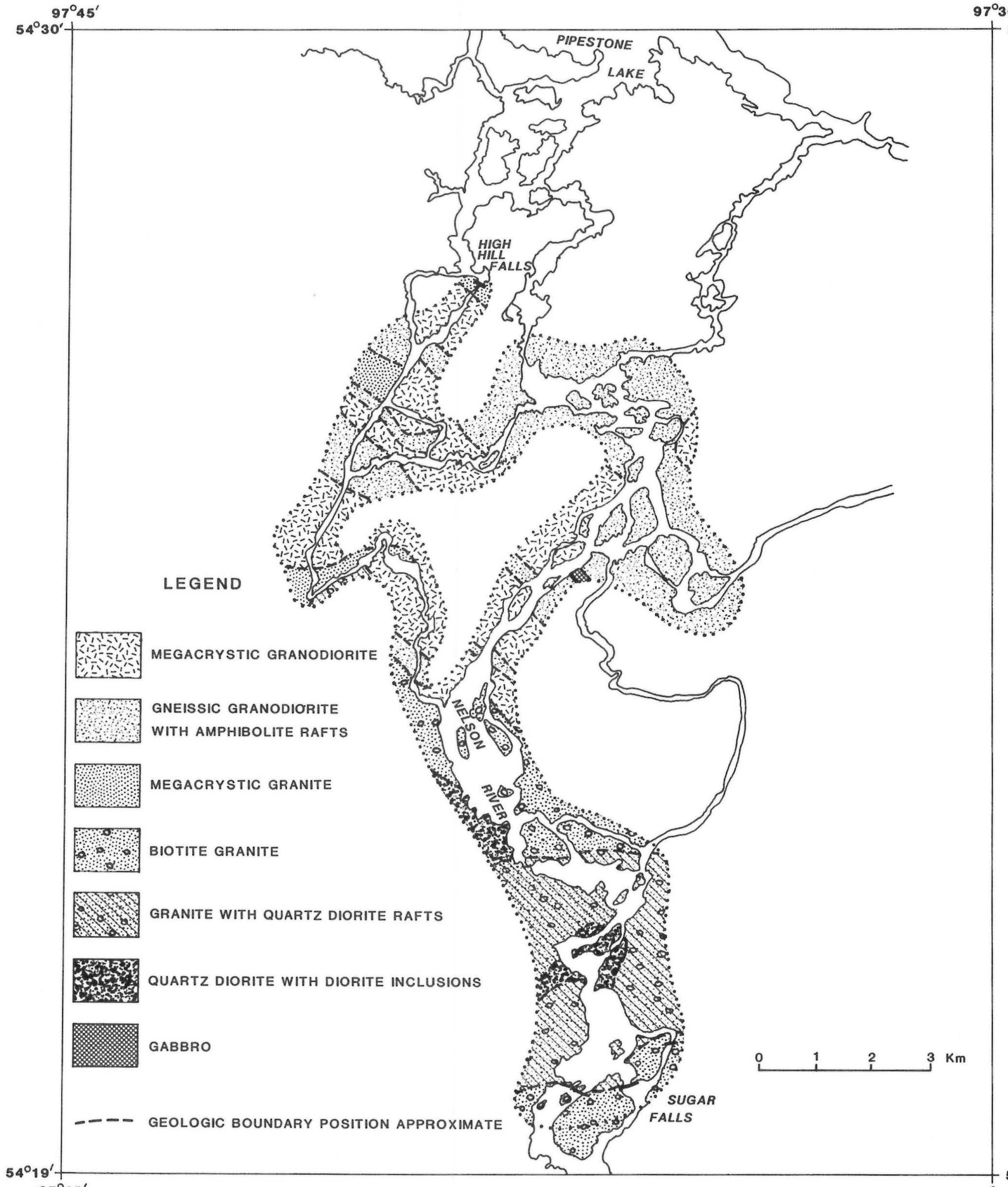

Figure GS-17-1: *Geology of the Nelson River, east channel.*

Table GS-17-1
NELSON RIVER, EAST CHANNEL: FIELD RELATIONS AND RELATIVE AGES OF ROCK TYPES (OLDEST TO YOUNGEST)

Rock Type	Major phase	Inclusion	Veins / dykes	Contains inclusions of rock types:
1. Metasandstone		X		-
2. Amphibolite		X		-
3. Gabbro		X		2
4. Diorite		X		2
5. Quartz diorite		X		2, 4
6. Tonalite-quartz diorite		X		-
7. Megacrystic granodiorite	X			2, 3, 4, 6
8. Hornblende monzodiorite		X		2, 4
9. Red megacrystic granite	X			2, 3, 4, 6, 7
10. Tonalite		X		2, 4, 8, 9
11. Gneissic granodiorite	X			2, 10
12. Biotite granite	X			4, 5
13. Fine grained granodiorite			X	9, 11, 12
14. Pegmatite			X	-
15. Aplitic granite, alaskite			X	-
16. Diabase			X	-

black fresh surface and shows elongate mafic clots ranging from 1 to 4 mm and feldspars to 8 mm. The diorite is intruded by granite and pegmatite.

QUARTZ DIORITE

Foliated, medium grey weathering quartz diorite is common in the central and southern parts of the map area. It is coarse- to very coarse-grained with 3 to 4 mm hornblende phenocrysts and red stained feldspars to 2 cm in a fine grained dark grey to black groundmass. The quartz diorite contains inclusions of diorite, fine grained amphibolite and schlieren. It occurs as rafts in, and is intruded by, 6 m sills of medium- to coarse-grained biotite granite as well as pegmatite and fine grained granodiorite.

TONALITE TO QUARTZ DIORITE

Medium grained, light grey weathering tonalite to quartz diorite occurs as 2 to 20 cm xenoliths, forming zones up to 6 m wide, in megacrystic granodiorite. The rock has a medium grey fresh surface and the weathered outcrop surface is characterized by 1 mm to 3 cm pits.

HORNBLENDE MONZODIORITE

Agmatized 4 m xenoliths of leucocratic hornblende monzodiorite occur in aplitic granite, fine grained light grey to white weathering tonalite, fine grained granodiorite and medium- to coarse-grained pink granodiorite. The monzodiorite is coarse grained, white weathering and contains inclusions of amphibolite and diorite. The rock contains 4 mm to 1 cm pink potassium feldspar, plagioclase to 4 mm and 1 mm to 1 cm hornblende.

TONALITE

Tonalite occurs as inclusions to 2 m wide in medium grained gneissic granodiorite. The tonalite is light grey-buff to pinkish white weathering and fine- to medium-grained (locally coarse grained). The rock is massive to foliated, and intrudes and rafts hornblende monzodiorite and red megacrystic granite. The weathered surface shows scattered, white feldspars ranging from 1 to 8 mm. Joint surfaces show pink hematite staining. Diorite and fine grained amphibolite rafts occur within the tonalite. The tonalite is agmatized by light pink aplitic granite. Locally, intrusion breccia is formed by injection of fine- to medium-grained granodiorite. Granodiorite and small pegmatite veins also intrude the tonalite.

III. Veins and dykes:

FINE GRAINED GRANODIORITE

Light grey to buff to pinkish and white weathering tonalite to granodiorite is one of the youngest phases in the area. It is fine- to medium-grained, homogeneous, equigranular and massive. The rock is quartz-rich and occurs as veins to 2 m intruding the main phases of gneissic, megacrystic granodiorite and granite. It is cut by veins of aplite and pegmatite and contains hornblende monzodiorite and gabbro rafts.

PEGMATITE

Small pink pegmatite dykes are common on most exposures. They range from 5 cm to 5 m wide (averaging 1 m). Rare element enriched minerals were not observed in any of the dykes.

PINK APLITIC GRANITE, ALASKITE

Buff to pink alaskite occurs as 1 cm to 2 m veins intruding and rafting tonalite and hornblende monzodiorite. It is generally associated with pegmatite and fine grained granodiorite veins. Some alaskite veins cross-cut some pegmatite dykes

DIABASE

Diabase dykes of the Molson swarm (Scoates and Macek, 1978) are the youngest phase in the area. The dykes are very fine grained and mafic to ultramafic in composition. The diabase is dark grey-green to brownish weathering. The dykes are 15 cm to 3 m wide and generally trend north to northeast. Some have been sheared and truncated by younger faults.

A coarse grained, homogeneous, equigranular, grey buff granophyre also occurs. It is massive and quartz-poor with a dark fresh surface and contains disseminated sulphides.

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GS-18 LEAD-ZINC POTENTIAL IN PALEOZOIC ROCKS; NORTHERN INTERLAKE REGION: SPRING AND CREEK WATERS AND SEDIMENTS

by W.D. McRitchie

McRitchie, W.D. 1989: Lead-zinc potentialin paleozoic rocks; northern Interlake region: spring and creek waters and sediments; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The northern Interlake region of Manitoba contains abundant and widespread outcrops of Silurian and Ordovician dolomite, together with a largely subsurface drainage system (Fig. GS- 18-1). These attributes make it well suited to stratigraphic and karst studies (Sweet, *et al.*, 1988), as well as a prime target for geochemical investigations looking for indicators of Mississippi Valley Type (MVT) lead-zinc mineralization.

The following geochemical investigation of spring and stream waters, and sediments, collected from the eastern "Ordovician" coastal plane adjacent to Lake Winnipeg, is part of a broader and longer term evaluation of the region being undertaken by the Geological Services Branch in cooperation with individuals of the Parks Branch, and the Museum of Man and Nature, researchers at the University of Winnipeg and the Speleological Society of Manitoba, (report GS-19, this volume).

In addition to the geochemical study of spring and creek waters and sediments, five stratigraphic reference holes (evenly spaced between Microwave Road and Capstan Point) were drilled to the base of the Ordovician (Fig. GS-18-1). These, linked with private sector exploration holes, now provide a virtually complete "fence" for correlating Paleozoic sequences south from Little Limestone Lake, to those south of Grand Rapids. In addition to providing stratigraphic information the drill core will also be split for multi- element geochemical analysis of insoluble residues, following the procedures used by Erickson *et al.* (1989) in their evaluation of the Harrison Quadrangle, Arkansas and Missouri.

Future geochemical studies will entail, more extensive sampling of springs at the base of the overlying Silurian escarpment, both north and south of Grand Rapids.

A fourth component of the studies conducted during 1989, was the implementation of a synthetic aperture radar (SAR) survey over the region by the Radarsat Office of the Canada Centre for Remote Sensing. The survey (Fig. GS-18-2) was conducted at the request of the Geological Services Branch, and is part of a joint federal/provincial initiative to evaluate applications of this technology to various types of resource programming.

Imagery received in mid-August suggests it may be possible to trace major scarps throughout the region, giving an added element of reliability to stratigraphic correlations based solely on apparent lithological similarities. Major linears that strike 020° may reflect post-Paleozoic tectonism hitherto inferred in the region from regional changes in strike related to the Moose Lake Syncline (Fig. GS-18-3).

WATER AND SEDIMENT SAMPLING PROGRAM

Creek waters and sediments

Sediment and water samples were collected (August 1 and 2) from near the outlets of eight creeks (Fig. GS-18-1 and Table GS-18-1) flowing into the northwest corner of Lake Winnipeg, between Grand Rapids and Limestone Bay. The creeks drain a large area of Paleozoic dolomites forming the uplands region between Cedar and Moose lakes in the west, and Lake Winnipeg in the east. Most of the uplands (elevations locally exceed 295 m, A.S.L.) are underlain by Silurian dolomites with scattered perched lakes and little if any surface drainage. The eastern edge of the Silurian plateau is delineated by prominent northeast and east-facing scarps overlooking a lower, relatively flat, "Ordovician" coastal plain. The creeks represent the eastern confluence of dendritic drainage systems flowing across the coastal plain. They originate in springs rising from the base of the "Silurian" escarpment at elevations between 240 m and 270 m (A.S.L.). Two of the creeks, Eating Point and Buffalo, drain spring-fed lakes of appreciable size.

One litre water samples were collected in sterilized nalgene bottles at sites upstream from the outlets into Lake Winnipeg. In all cases the streams exhibited substantial flow rates and discharge plumes into the lake waters. Sediment samples, from 3-4 kilograms, were hand-scooped from the bed of the creeks at sites upstream from the outlets, which were commonly channeled through beach sand ridges with abundant dolomite shingle and cobbles. Only in the case of Cypress Creek could it be said that the river bottom sediments appeared part of the active sediment load. In all other settings the creeks were meandering drainage channels cutting through open low areas lined with sedge, horsetails, and willow clumps. Wherever possible an effort was made to minimize the amount of organic matter in the samples, but in most cases 20-30% was unavoidable.

pH readings were taken at all sites using a portable pH meter, but continuing drifts in the readings made these results suspect and the results are not reported. All pH readings are being checked in the laboratory along with other analyses undertaken in the William Ward Technical Services Laboratory, Logan Avenue, Winnipeg.

Spring waters and sediments

Water and sediment samples were also collected (August 19-20) from six springs at the headwaters of the Woody Point Creek (Fig. GS-18-4d) and four at the headwaters of the Sturgeon Gill Creek and Hungry River (Fig. GS-18-4a). Four additional springs were sampled (September 9 and 10) to provide infill coverage from the headwaters of the Hungry River and Sturgeon Gill Creek and a feeder spring to Buffalo Lake (Fig. GS-18-4b and GS-18-4c). An additional seven springs in the region south of Buffalo Creek were sampled by R. Betcher (Water Resources Br.), October 3rd and 4th.

pH and temperature readings were taken using a HACH 1 pH meter. All field data are reported in Table GS-18-1, and laboratory data in Table GS-18-2.

ACKNOWLEDGEMENTS

SSM* members are thanked for their assistance in undertaking the sampling program, Hugo Copper in particular for his support in the reconnaissance of the Lake Winnipeg shoreline, the geology of which was last documented by Dowling (1900).

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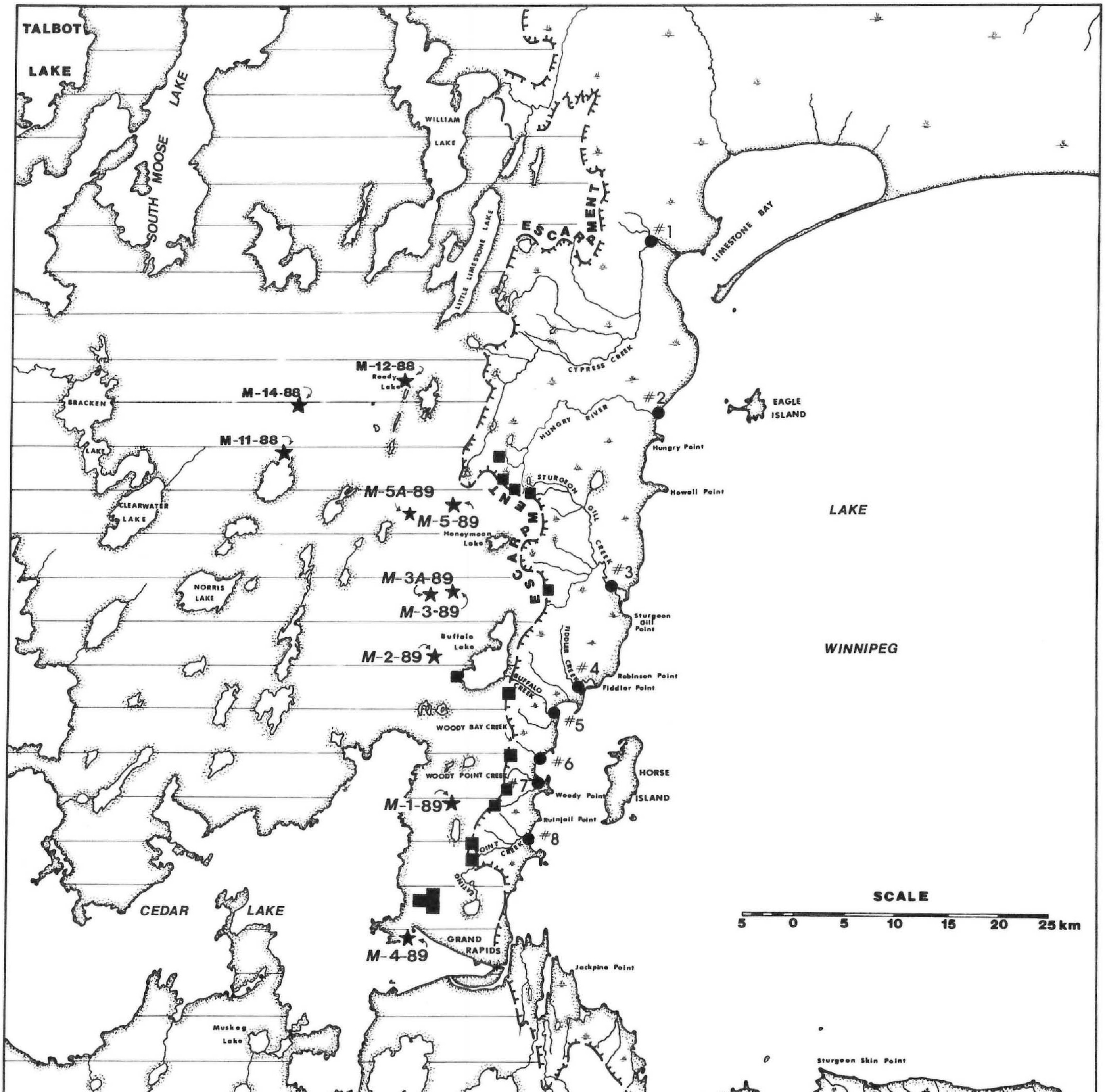

Figure GS-18-1. *Grand Rapids Uplands investigations 1989: a) Stratigraphic drill locations (solid stars); b) water and stream sediment sampling locations (solid circles); and c) spring sample locations (solid squares). Accurate locations for springs shown in Fig. GS-18- 4a, 4b, 4c and 4d).*

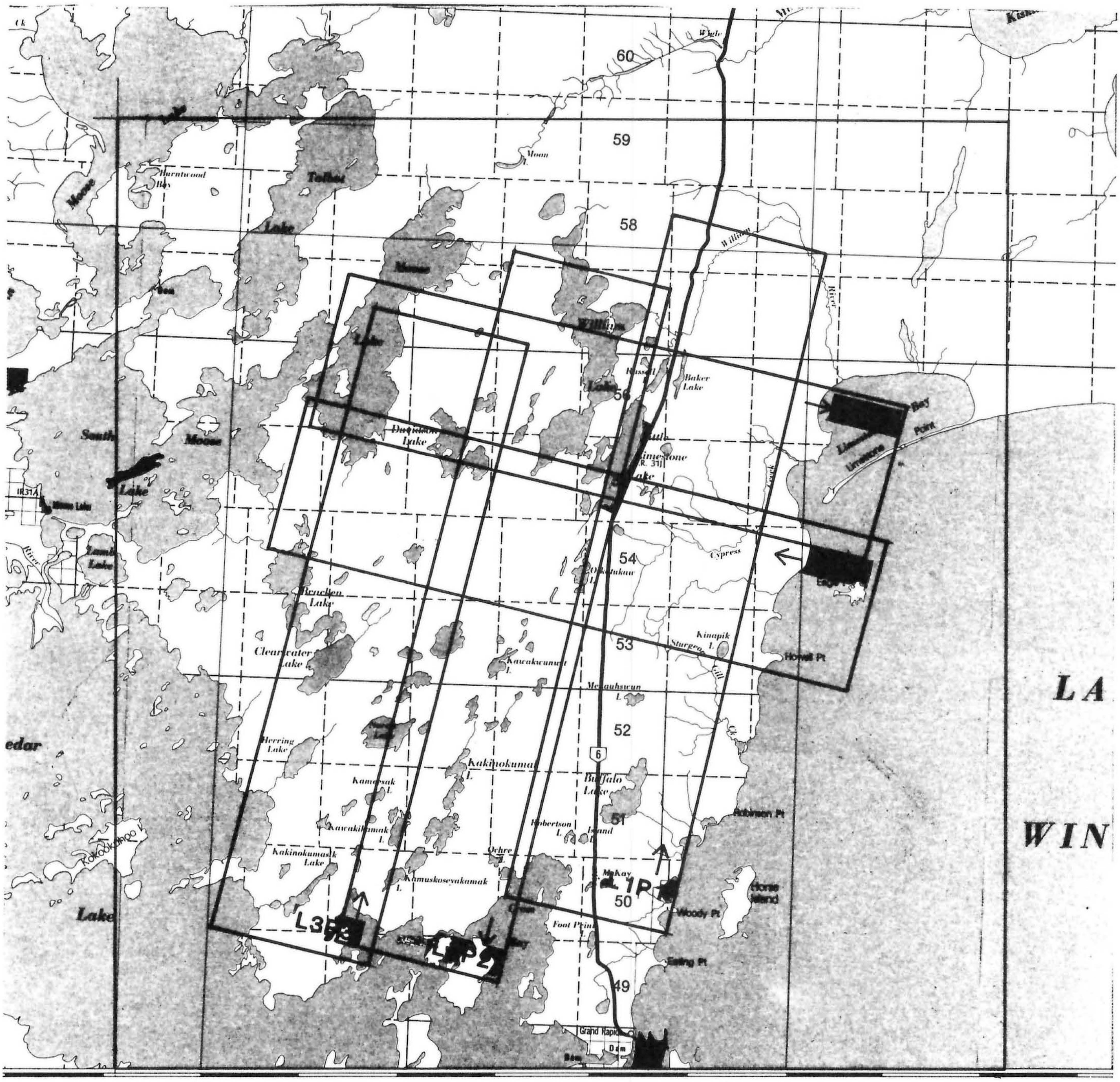

Figure GS-18-2: *Grand Rapids Uplands - Airborne radar surveys (SAR) showing swath widths and look directions.*

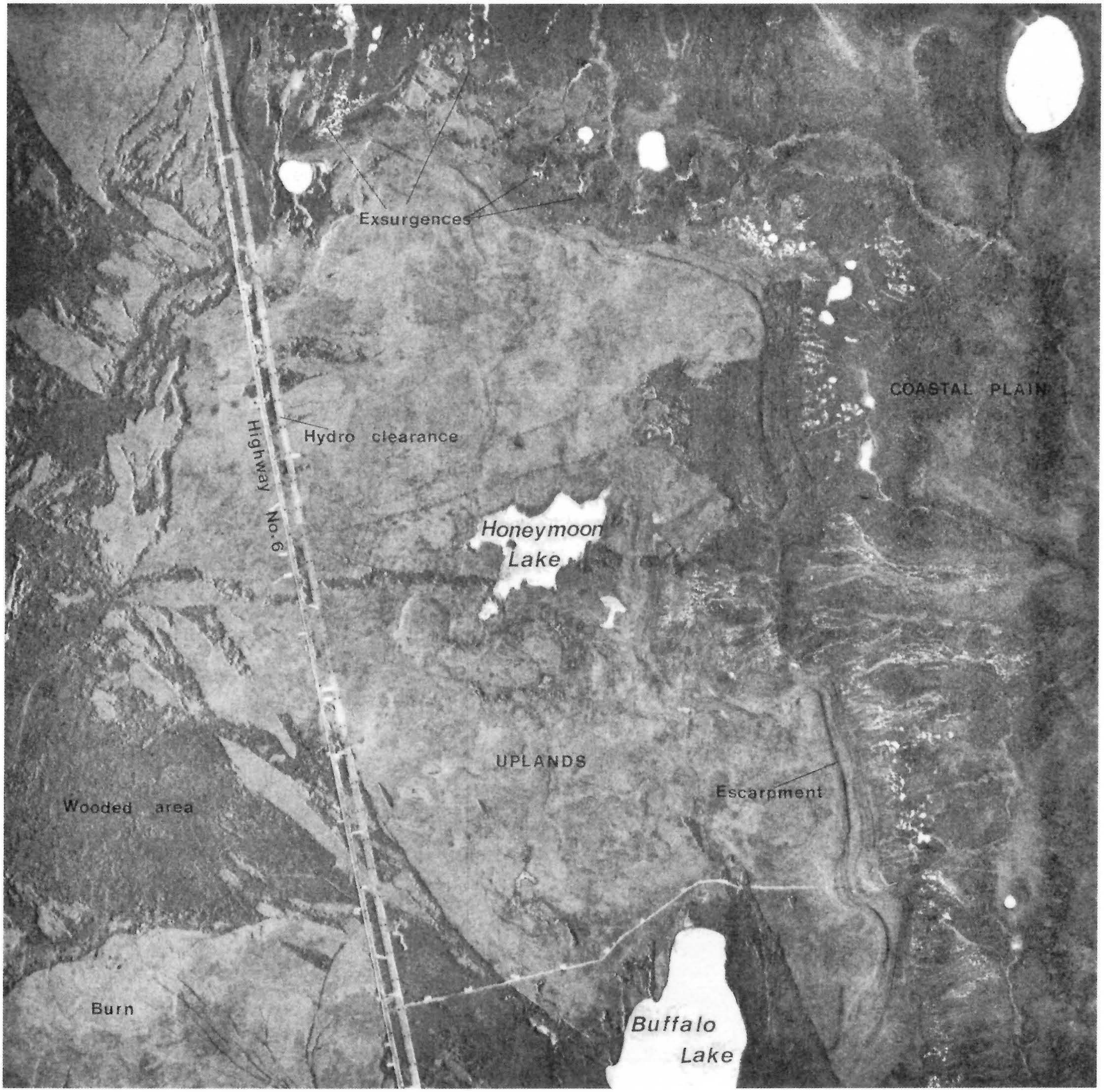

Figure GS-18-3: *Example of SAR imagery from Honeymoon Lake area (Grand Rapids Uplands) showing Silurian escarpment, coastal plain drainage, and sharp distinction between burn and non-burn areas. Highway #6 and hydro transmission lines in left centre of image. (Note radar discrimination of individual pylons).*

Table GS-18-1
SAMPLE LOCATIONS AND FIELD MEASUREMENTS

GRAND RAPIDS WATER SAMPLING PROGRAM

	Sample Type	Sample #	pH	T°C
Creeks/River (a)				
Cypress River	WS	WS04-1-1-89 and WS04-1-2-89		
Hungry River	WS	WS04-2-89		
Sturgeon Gill Creek	WS	WS04-3-89		
Fiddler Creek	WS	WS04-4-89		
Buffalo Creek	WS	WS04-5-89		
Woody Bay Creek	WS	WS04-6-89		
Woody Point Creek	WS	WS04-7-89		
Eating Point Creek	WS	WS04-8-89		
Springs (b)				
Woody Point Creek South	W	WS04-10-89	7.99	6.8
Woody Point Creek	WS	WS04-11-89	7.71	8.7
Woody Point Creek	W	WS04-12-89	7.68	5.6
Woody Point Creek	W	WS04-13-89	7.75	6.1
Woody Point Creek outwash fan	S	WS04-14-89	-	-
Woody Point Creek	WS	WS04-15-89	7.74	5.6
Woody Point Creek	W	WS04-16-89	7.72	5.8
Sturgeon Gill Creek (Eden grove)	WS	WS04-17-89	7.87	5.7
Hungry River (medial grove)	W	WS04-18-89	7.65	5.7
Hungry River (medial grove west)	W	WS04-19-89	7.62	6.7
Hungry River (West grove)	W	WS04-20-89	7.72	6.5
Hungry River (West tributory north)	W	WS04-22A-89	6.97	7.0
Hungry River (West tributory south)	W	WS04-22B-89	6.93	7.0
Sturgeon Gill Quarry	W	WS04-23-89	8.29	12.0
Buffalo Lake	W	WS04-24-89	7.33	5.4
Eating Point Creek	W	GR-SPRING #1	8.04	3.7
Eating Point Creek	W	GR-SPRING #2	7.83	5.4
Eating Point Creek	W	GR-SPRING #3	7.76	5.2
Eating Point Creek	W	GR-SPRING #4	7.92	7.3
Eating Point Creek	W	GR-SPRING #5	8.22	5.0
Woody Bay	W	GR-SPRING #6	7.92	7.1
Buffalo Creek	W	GR-SPRING #7	7.72	8.2

W - water; S - sediment

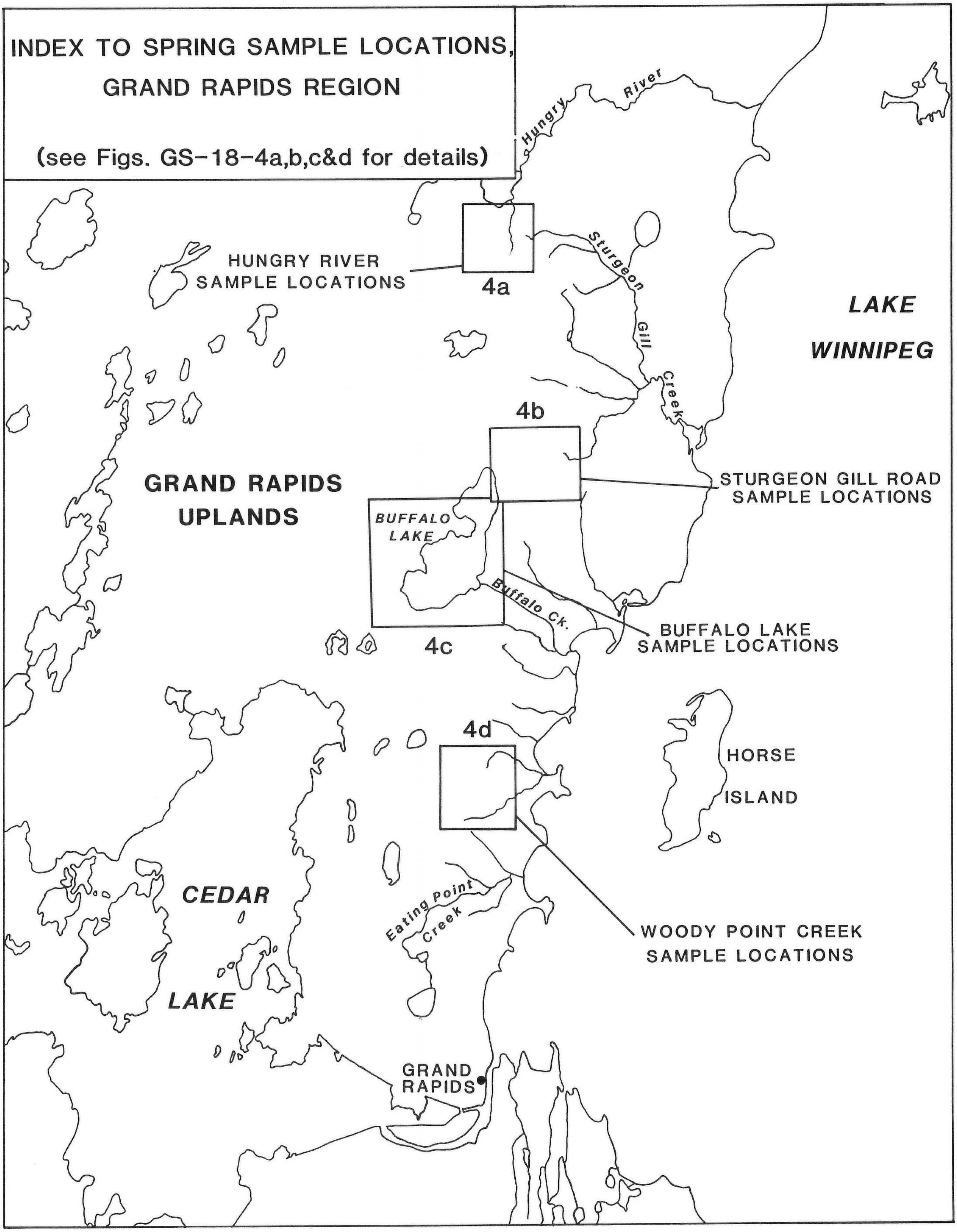

Figure GS-18-4: Index to spring sample locations, Grand Rapids region.

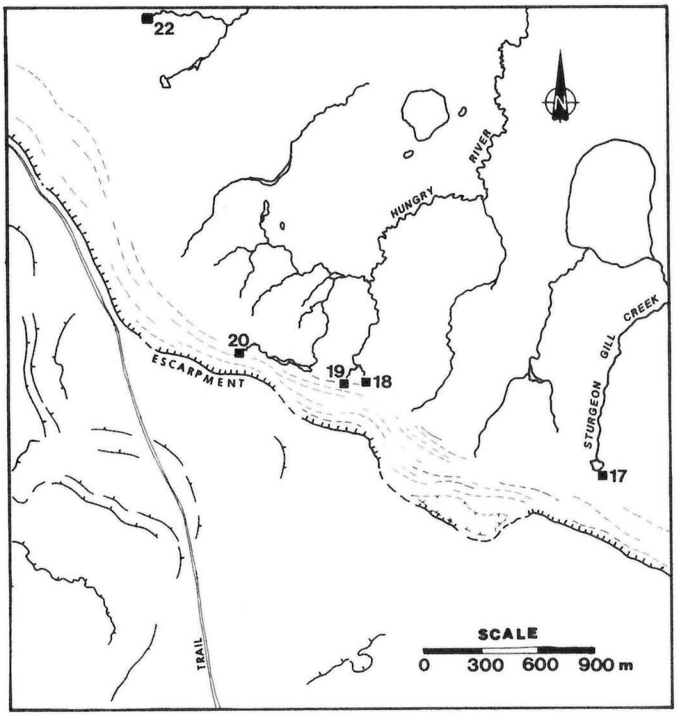

Figure GS-18-4a: Location of spring samples at the headwaters of Sturgeon Gill Creek and Hungry River

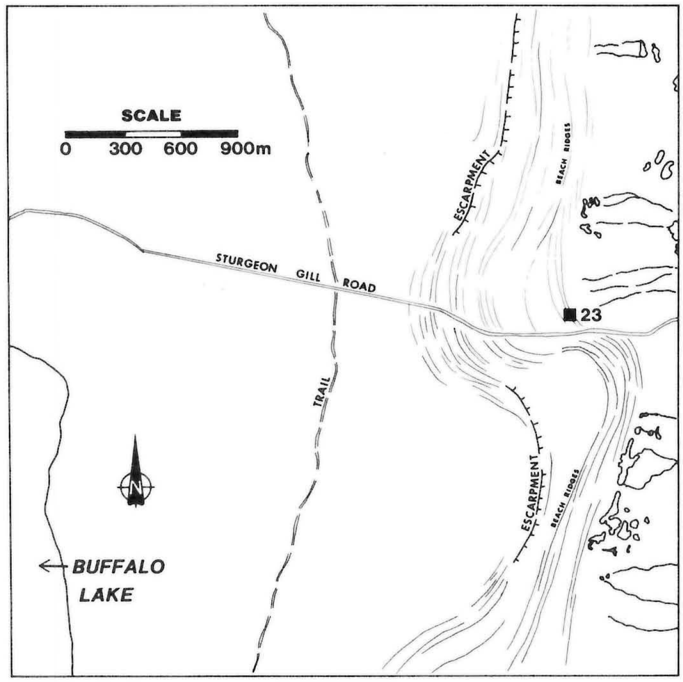

Figure GS-18-4b: Location of spring emerging from the base of beach ridges adjacent to Sturgeon Gill road.

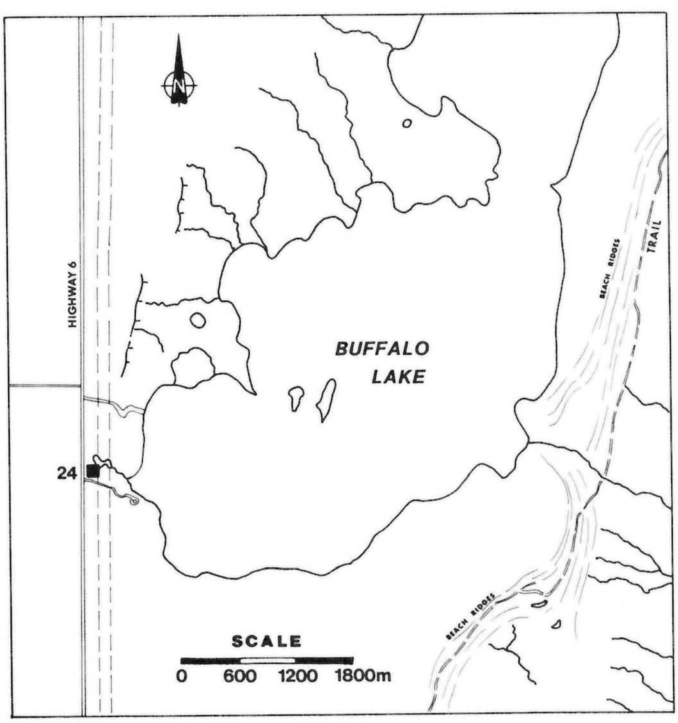

Figure GS-18-4c: Location of spring feeding Buffalo Lake.

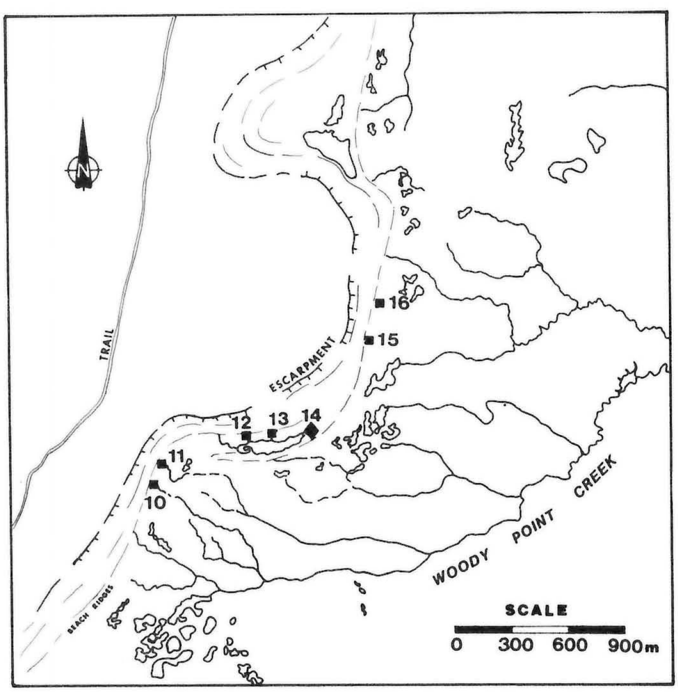

Figure GS-18-4d: Location of spring samples at the headwaters of Woody Point Creek.

Table GS-18-2

ANALYSES OF CREEK AND SPRING WATERS FROM GRAND RAPIDS REGION, MANITOBA

		Cu	Ni	Zn	Pb	Fe	Mn	F	pH
Creek									
	04-1-1	0.01	0.005	0.01	0.005	0.12	0.07	0.18	8.10
	04-1-2	0.01	0.005	0.01	0.005	0.14	0.07	0.19	8.15
	04-2	0.01	0.005	0.01	0.005	0.09	0.02	0.20	8.21
	04-3-1	0.01	0.005	0.01	0.005	0.21	0.03	0.21	8.27
	04-3-2	0.01	0.005	0.01	0.005	0.33	0.04	0.22	8.09
	04-4	0.01	0.005	0.01	0.005	0.14	0.02	0.26	7.84
	04-5	0.01	0.005	0.01	0.005	0.31	0.02	0.17	7.85
	04-6	0.01	0.005	0.01	0.005	0.10	0.02	0.18	8.00
	04-7	0.01	0.005	0.01	0.005	0.05	0.02	0.18	8.16
	04-8-1	0.01	0.005	0.01	0.005	0.07	0.02	0.24	8.28
	04-8-2	0.01	0.005	0.01	0.005	0.06	0.02	0.26	8.28
Spring									
	04-10	0.01	0.005	0.01	0.005	0.02	0.02	0.17	7.74
	04-11	0.01	0.005	0.01	0.005	0.02	0.02	0.18	7.53
	04-12	0.01	0.005	0.01	0.005	0.02	0.02	0.17	7.39
	04-13	0.01	0.005	0.01	0.005	0.02	0.02	0.18	7.44
	04-15	0.01	0.005	0.01	0.005	0.02	0.03	0.15	7.48
	04-16	0.01	0.005	0.01	0.005	0.02	0.02	0.16	7.45
	04-17	0.01	0.005	0.01	0.005	0.02	0.02	0.11	7.48
	04-18	0.01	0.005	0.01	0.005	0.02	0.02	0.14	7.41
	04-19	0.01	0.005	0.01	0.005	0.02	0.02	0.13	7.40
	04-20	0.01	0.005	0.01	0.005	0.02	0.02	0.12	7.41

Results for Cu, Ni, Zn, Pb, Fe Mn and F reported in mg/l.

GS-19 KARST INVESTIGATIONS IN MANITOBA'S INTERLAKE REGION

by P. Voitovici[1] and W.D. McRitchie

Voitovici, P. and McRitchie, W.D. 1989: Karst investigations in Manitoba's Interlake region; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

An appraisal of karst features in Manitoba's Interlake was continued throughout the February-October period by members of the Speleological Society of Manitoba (SSM), in cooperation with individuals from several government agencies including the provincial Geological Services Branch.

Significant new cave discoveries were made in the Gypsumville and Gypsum Lake regions where unique "Cockpit Karst" topography is developed in Jurassic gypsum deposits lying within the Lake St. Martin structure.

Several new caves were also located and mapped in the Grand Rapids Uplands, and over a dozen other occurrences reported from the Southern Interlake, on Peonan Point, and near Mantagao, Spence and Highrock lakes, Fairford, Hodgson and Dallas.

At the time of writing more than 60 new caves have been added to the inventory established in 1988, bringing the total to over 120. Although most fall within the category outlined during the previous year (i.e. less than 100 m in length and 10 m deep), **Labyrinth Cave** east of Gypsum Lake possesses a total corridor length of 189 m and as such represents the longest cave discovered thus far in the province. Over 1km of new passageways were explored during the year (Table GS-19-1).

Following earlier reports of sinkholes in the Gypsumville area (Wallace and Greer, 1927; Brownell, 1931; Bannatyne, 1959; Hoque, 1967), the discovery of extensive underground solution corridors by the SSM is a significant new contribution, opening up a totally virgin area for future exploration and research.

The assistance and guidance provided by Jane and Warren Rawluk of Gypsumville, in gaining information, and access to these areas was especially appreciated, as was the warm hospitality provided on all visits to the region. Thanks also go to Lillian and Len De Lafuente for assisting the search in the Spence Lake region, to Clarence Sinclair who led us to caves near Dallas, and to Chief Ed Anderson and Angus Woodford of Fairford who not only shared a little of their history with us during the February "dig" at the **Snakepit**, but who also improved access to the site making the job that much easier.

As in previous years, a special acknowledgement is also made to the members of the SSM, for their continued efforts and enthusiasm in exploring for, and documenting, Manitoba's underground heritage. G. Sweet made several suggestions which added greater accuracy to the statements made in the report.

The society's activities in the Grand Rapids region complemented other ongoing research including Karst studies by G. Sweet (University of Winnipeg), a study of bat populations and habitats by J. Dubois (Museum of Man and Nature), stratigraphic investigations and drilling by R.K. Bezys (MGSB), and geochemical studies of spring and creek waters and sediments (McRitchie, Report GS-18, this volume).

OUTLINE OF ACTIVITIES

Southern Interlake

Information provided by the residents of the Fairford Indian Reserve pointed to the existence of an extensive underground passageway leading from a sinkhole on the reserve, 3 km to the banks of the Dauphin River. (The sink was also recorded in Baillie's 1950 field notes, as was the local tale of a passageway leading underground to the river.) A snake pit located on the south side of the road through the reserve, opposite the school, was cited to be the entrance, but considerable debris had been thrown into the shaft blocking any access. The shaft was excavated to a depth of 5 m before being abandoned in naturally stratified Holocene infill deposits. At the base, the vertical, joint-controlled shaft opened laterally into a horizontal solution cavity largely plugged with soft sediments, to the point where the open space was only 4 m long and 30-40 cm high (Fig. GS-19-1).

A small cave 300 m to the south of the snake pit, was excavated to a depth of about 3 m, but it also showed no evidence of opening up. Several other sinks reported from this district will be investigated in the future.

Numerous other referrals were received from local residents in the Southern Interlake region including five caves at Highrock Lake, two near the southern end of Peonan Point on Lake Manitoba, one on Spence Lake, two north of Highway 325 east of Ashern, and two southeast of Dallas that were mapped later on in the season. Three additional caves were also found in the St. George Lakes area, northeast of **Window Cave** (Sweet *et al.*, 1988).

Sinkholes reported in the Leifur area (Bannatyne, 1959), 18 km north of Amaranth, are shallow depressions with no evidence of open drain holes nor potential cave entrances.

Gypsumville

A cursory examination of the gypsum deposits at Gypsumville confirmed the existence of extensive solution pits east of the quarry, 3 km north of town. Although previous reports on the area had made reference to these features, only Tyrrell's 1888 report indicated the associated presence of cave entrances, over 40 of which were counted in the first few days of the current exploratory traverses (Fig. GS-19-2).

A systematic mapping program was initiated, and by summer's end over 20 of the caves had been surveyed (Fig. GS-19-3 ,in pocket). The extraordinary concentration of sinkholes in this region is almost unique for gypsum deposits in Canada, the only comparable localities being in Alberta (Tsui and Cruden, 1984), and Newfoundland (Sweet, 1979).

The sinkholes range up to 40 m in diameter and 10 m in depth. Most are funnel-shaped, although vertical-walled solution- grooved shafts also occur. The density of sinkholes is such that only narrow ridges persist between many of the subjacent sinks, the sides of which are generally smooth and till covered. Bedrock is commonly exposed in one or more of the banks and these outcrops form the caprocks to the small cave entrances.

The caves are either long, sinuous, cylindrical "phreatic" tubes, or "vadose" mazes where the passageways follow a complex interconnecting rectilinear pattern controlled by the main joints. The northern end of the **Long Crawl** (Fig. GS-19- 3, #1) exhibits a gradational buildup of relatively recent sediments suggesting a dominantly north to south flow of groundwaters in the main underground channels.

Typically all caves are shallow (2-4 m below the surface) and bottom at about the same level. Some cave ceilings locally break through into the overlying glacial till. The gypsum lithologies vary widely, and a water table control on the solution appears more likely than preferred solution of a more soluble layer. Brownell(1931) reports that "quarry operations carried out after the water table was lowered about 9 feet revealed horizontal water channels in the gypsum". It is conceivable therefore that (in the quarry area at least) the abandonment of the caves by the water was a man- induced phenomena. At the present time all of the caves are totally dry except for minor water accumulating from the melting of ice plugs that encircle the entranceways until late May. Strong airdrafts are present in many caves indicating a widespread interconnecting complex of underground cavities.

Although the gypsum beds are essentially flat lying, numerous open asymmetrical folds are present (see Bannatyne, 1959, and Wardlaw *et al.*, 1969, for a discussion of these features) and locally these structures appear to influence the degree and form of cave development. Some of the larger chambers appear to have resisted incasion or breakdown because of the natural stability of roof slabs braced, and arched on either side of an anticlinal closure.

[1]Speleological Society of Manitoba (SSM)

Table GS-19-1
CAVES, SINKHOLES AND TRENCHES IN THE INTERLAKE REGION, STATUS OF INVESTIGATIONS FOR DISCOVERIES MADE DURING 1989

Cave Name	Unconfirmed Report	Located	Sketched	Mapped	Excavation Required	L (Metres)	D (Metres)
GRAND RAPIDS:							
Ice Organ	....	xxxx	....	xxxx	....	36.0	8.6
Mouldy-moth (Microwave #3)	....	xxxx	....	xxxx	....	12.5	3.4
Cliff Cave	....	xxxx	xxxx	....	....	10.0	7.0
Drop-in	....	xxxx	xxxx	....	....	11.0	2.4
Chain	....	xxxx	....	....	....	3.5	2.0
Lookout Crevice	....	xxxx	....	....	....	43.0	5.0
Wet Memory	....	xxxx	....	....	....	2.0	1.0
Skull trench	....	xxxx	....	....	....	15.0	5.0
					Subtotal	133.0	
GYPSUMVILLE:							
Crystal Kingdom	....	xxxx	....	xxxx	....	19.5	1.5
Long Crawl	....	xxxx	....	xxxx	....	125.5	3.0
Octopus	....	xxxx	....	xxxx	....	46.0	1.2
Log Barricade	....	xxxx	xxxx	....	....	-	-
Short Crawl	....	xxxx	....	xxxx	....	23.0	1.4
Moth's Cellar	....	xxxx	....	xxxx	....	23.5	2.0
Jaws	....	xxxx	....	xxxx	....	16.0	1.5
Snuggy Crawl	....	xxxx	....	xxxx	....	19.0	1.5
Honeypot	....	xxxx	....	xxxx	....	37.0	1.8
Bear's Den	....	xxxx	....	....	....	14.0	0.5
Too-tight	....	xxxx	....	xxxx	....	-	-
Iceslide	....	xxxx	....	xxxx	....	38.0	1.5
Maze	....	xxxx	....	xxxx	....	76.5	1.2
Small Maze	....	xxxx	....	xxxx	....	31.0	1.0
Vertebrae	....	xxxx	....	xxxx	....	23.0	0.5
Spike	....	xxxx	....	xxxx	....	16.5	0.5
"Y"	....	xxxx	....	xxxx	....	33.0	1.4
Chamber	....	xxxx	....	xxxx	....	55.0	1.4
Tunnel	....	xxxx	....	xxxx	....	7.0	1.0
Transverse	....	xxxx	....	xxxx	....	14.0	0.5
Steepsink	....	xxxx	xxxx	....	....	-	-
Cliff	....	xxxx	xxxx	....	....	-	-
Slab	....	xxxx	....	xxxx	....	16.5	3.6
Bear Den	....	xxxx	....	xxxx	....	14.0	0.5
Nine foot pole	....	xxxx	....	xxxx	....	12.5	1.8
					Subtotal	660.5	
GYPSUM LAKE EAST:							
Stormcloud	....	xxxx	....	....	....	-	-
Phantom Bear	....	xxxx	xxxx	....	....	39.5	5.5
Labyrinth	....	xxxx	....	xxxx	....	189.0	4.8
Zig-zag	....	xxxx	xxxx	....	....	24.5	-
Meander	....	xxxx	....	....	....	-	-
Crystal Palace	....	xxxx	....	....	....	-	-
Dusty	....	xxxx	....	....	....	15.0	2.0
					Subtotal	268.0	
FAIRFORD:							
Snakepit	....	xxxx	....	xxxx	....	18.3	4.8
Cockpit	....	xxxx	....	....	....	3.0	1.5
Baillie's pit	....	....	....	....	....	-	-
					Subtotal	21.3	
DALLAS:							
Doug's Den	....	xxxx	....	xxxx	....	10.5	4.5
Clarence's Cave	....	xxxx	....	xxxx	....	11.0	4.0
					Subtotal	21.5	

TABLE GS-19-1
CAVES, SINKHOLES AND TRENCHES IN THE INTERLAKE REGION, STATUS OF INVESTIGATIONS FOR DISCOVERIES MADE DURING 1989

Cave Name	Unconfirmed Report	Located	Sketched	Mapped	Excavation Required	L (Metres)	D (Metres)
SPENCE LAKE:							
The Tomb	....	xxxx	....	xxxx	....	13.5	1.8
					Subtotal	13.5	
HODGSON:							
#1	....	xxxx	....	....	....	-	-
#2	....	xxxx	....	....	....	-	-
#3	....	xxxx	....	....	....	-	-
					Overall Total	1117.8	

Others reported from Mafeking(1), Highrock (5), Peonan Point (2), Mantagao (3), Ashern Road east (2), and Vidir (1).

Gypsum Lake east

Other gypsum occurrences were identified in earlier descriptions of the region east of Gypsum Lake (Brownell, 1931). Eugene Syrotiuk, a hunter in the region, reported seeing caves and shafts during his ventures into the area. Accordingly, several visits were made to this relatively remote and poorly documented sector of the Lake St. Martin structure (Fig. GS-19-4).

The region proved to contain even more striking examples of "Cockpit Karst" than those observed north of Gypsumville, with relief ranging up to 15 m and sinkholes commonly several tens of metres in diameter, with local mega-sinks over 100 m across. Shafts with vertical solution-grooved walls are present but are more rare than the typical funnel-shaped dolines. This summer's inspection has covered only a small fraction of the area, much of which is covered by dense undergrowth of hazelnut and alder with a canopy of mature poplar spotted with spruce clumps.

Six of the larger caves (Fig. GS-19-5) were examined in some detail, and once again excellent examples of both rectilinear "vadose", and tube-like "phreatic" passageways were documented (Figs. GS-19-6 and GS-19-7). No speleothems were recorded, but unique globular masses of gypsum in the roof of **Stormcloud Cave** (Fig. GS-19-8) are thought to represent a peculiar form of diagenetic nodule development referred to as "chicken wire texture", rather than "cave clouds" (Hill and Forti, 1986), which owe their origins to precipitation . Most caves again appear to bottom at about the same level (4-5 m below the surface) and a water table control on solutioning appears to have been the principal influence in the area. None of the caves examined thus far contain evidence of recently flowing water. Small static pools are fairly common, and **Labyrinth Cave** (Fig. GS-19-9) contains extensive passageways (Muddy Lane) floored by water-saturated gypsum mud (gypsite). Good sections of thinly interlayered red and white gypsum strata can also be observed in this cave, as can repeated small scale asymmetrical folds with a consistent sense of asymmetry (Fig. GS-19-10).

Crystal Palace contains fine displays of hexagonal ice pendants until well into July. The inner section of this cave is particularly dangerous and unstable with widespread indications of recent breakdown.

The large low entrance chamber is accessed through a vertical opening at the base of a 2.5 m deep, steep-walled, funnel- shaped doline. The chamber is approximately circular, 10-15 m in diameter and over 2 m high near its centre. A narrow ice- floored curvilinear passageway leads radially to the north and east. Halfway along this crawlway (6 m), a striking frozen waterfall of crenellated ice "flowstone" (Fig. GS-19- 11) is overshadowed by 1-1.5 m long ice stalactites. On the opposite (left) wall and roof the first display of nested, euhedral, hexagonal ice crystals (up to 8 cm individuals) forms a particularly photogenic display(see Fig. GS-19-12). High and to the left of the crawlway an overhanging ledge opens back into a broad low chamber containing an even more spectacular display of ice formations. The chamber is reached by continuing along the crawlway for another 6 m and then branching left (under a breakdown slab precariously perched on top of a small crumbly and soft looking chockstone) into the main room, which has been named Breakdown Chamber. This chamber has a central 1.5 m high pillar of layered buff gypsum. To the left of the pillar a 1.5 m high chamber stretches back 6-8 m towards the upper lip of the passage containing the crawlway. The ceiling and walls of the chamber are carpeted with a delicate, filamentous fretwork of large, euhedral, hexagonal ice crystals. The basal coating of crystals is 5-10 cm thick and generally of even thickness. Locally the surface is broken by bushlike outgrowths of ice crystals up to 20 cm in diameter, and more rare skeletal pendants that hang 40 cm down from the ceiling with perfectly formed (15 cm) ice crystals jutting perpendicularly from the main stem.

North and west of the pillar the room extends into a long 2 m high corridor lined and walled with chaotic breakdown blocks with extremely fresh surfaces indicating recent incasion (Fig. GS-19-13). This passageway continues for 7-8 m and thence another 15 m under a particularly shaky looking chockstone. Another arm of the cave is passable for 6-8 m in the opposite direction, with narrow extensions 10m beyond this.

Meander Cave, and **Zig-zag** (Fig. GS-19-14a) exhibit narrow rectilinear passageways with incised meanders stacked at numerous levels. Cave popcorn is abundant in **Meander Cave**. **Phantom-Bear Cave** (Fig. GS-19-14b) possesses two entrances and a large low chamber almost 15m in diameter.

During a late October visit to the area, bats were observed in **Stormcloud**, **Crystal Palace**, **Meander** and the **Long Crawl**.

Further work is planned east of Gypsum Lake, however, activities are currently on hold pending receipt of leaf-free and pre-snow aerial photography that will be used to assist the process of surveying the location of the caves in this densely vegetated region.

Grand Rapids

Geological Services Branch work in the Grand Rapids region gave increased emphasis to water and sediment sampling (see report GS-18, this volume), the main objective being to search for indications of lead and zinc mineralization in the subsurface. Samples are also being submitted for tritium analysis which will provide additional information on the underground residency times of the water emerging from the springs at the base of the Silurian escarpment.

Reconnaissance traverses aimed at finding new caves had only marginal success. Only four caves of note were discovered. **Ice Organ**, **Mouldy-Moth** (Fig. GS-19-15a and GS-19-16a), **Cliff** and **Drop-in**, as well as several other solution features, e.g. trenches, crevice caves and small solution cavities such as **Wet Memory Cave** and **Chain Cave**, both less than 5 m in depth. **Firecamp** and **Ice Cave** (Figs. GS-19-15b and 16b) were described more fully by Sweet *et al.* (1988).

During the traversing and sampling programs observations were made regarding drainage patterns and processes in the region. Although of a superficial nature, these records and impressions are presented as a supplement to more detailed and extensive accounts of the district's hydrology being prepared by G. Sweet as a Doctoral Thesis at McMaster University.

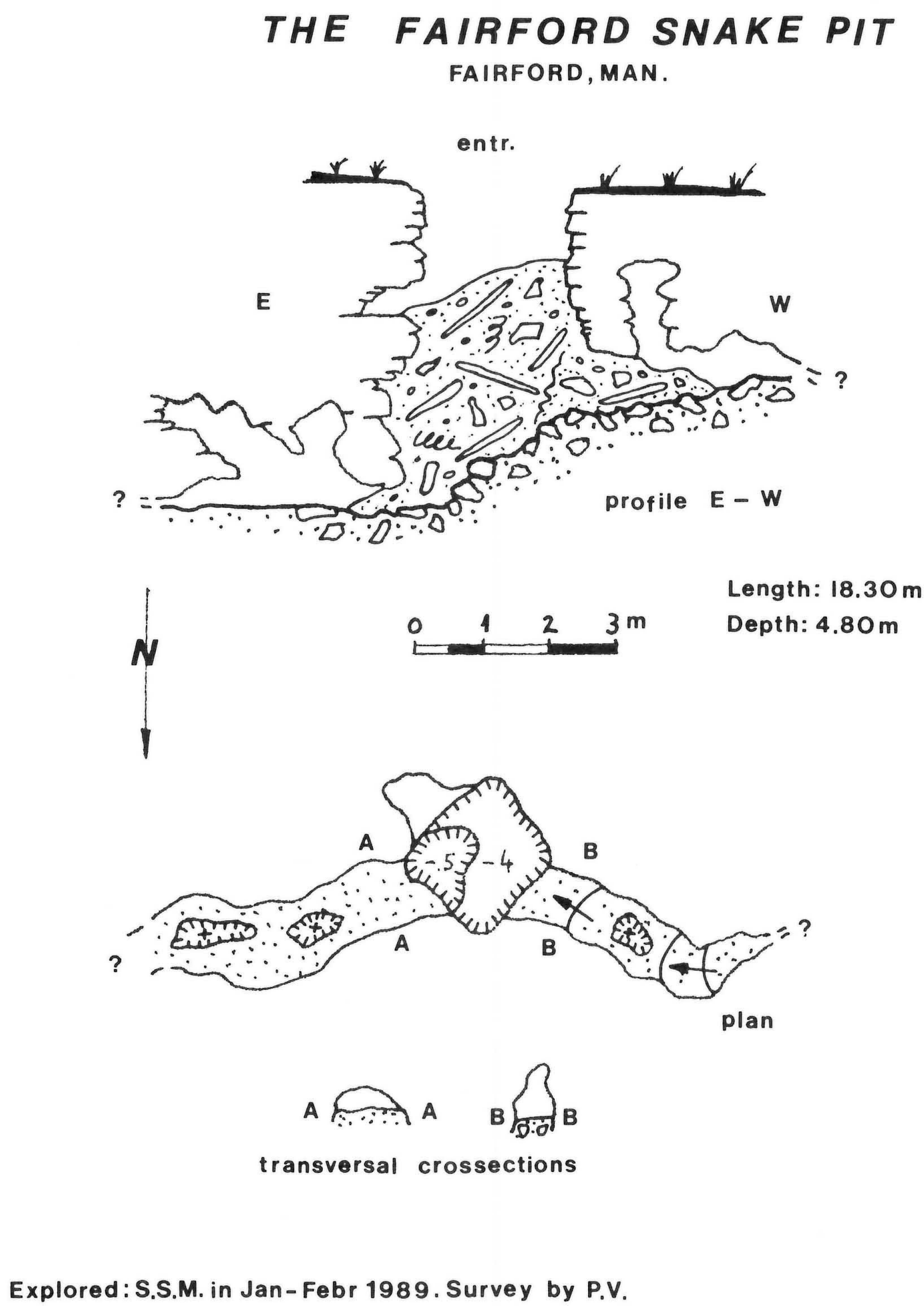

Figure GS-19-1: *Fairford Snake pit (map).*

Figure GS-19-2: *Typical sinkhole, gypsum bedrock exposure, and cave entrance, Gypsumville north-guarry region.*

The marked contrast between the dendritic surface drainage typical of the Ordovician coastal plane, and the virtual absence of an organized drainage system on the Silurian Uplands is a feature worthy of note.

North and west of Buffalo Lake the Uplands are characterized by extensive flat dolomitic pavement. Small, 1-2 m relief, scarps face east and northeast between Grand Rapids and Little Limestone Lake, and north, from Little Limestone Lake to Moose Lake. The monotony of the tableland is broken by scattered subround to elliptical and locally elongate clay- based perched lakes most of which possess broad sedge-lined margins reflecting their shallow nature as well as marked seasonal fluctuations in water level. By late spring many lakes that were filled with spring run-off have drained internally leaving dry sedge-lined depressions spotted by clumps of willow. Only a few of the larger lakes exhibit outflow drainage, and these persist throughout the ice-free season (e.g. Bracken, William, Buffalo and Eating Point lakes). The remainder appear to drain internally as a result of seepage through the underlying surficial sediments.

Elsewhere in the region elliptical depressions and more rare dry valleys, are lined with sedge and bordered by willows, with willow clumps scattered variously around across their surface. Isolated groves of tall poplar tend to cluster around the margins particularly in association with low spots or prominent dolines. The diameter of depressions ranges up to 500 m, and typically most are rimmed by a small escarpment 1-3 m high.

Close examination of the (polje-like) depressed areas commonly reveals second order drain holes up to 5 m in depth and 5-10 m in diameter. In late spring the drain holes exhibit evidence of active water flow either as radial runnels or concentric water lines in their clay-lined banks, or as flattened sedge carpets converging radially into the maw of the drain. Those drain holes deep enough to expose the underlying bedrock typically reveal a prominent open joint system variously enlarged into an active vadose passageway. All gradations are observed from shallow grass-lined hollows, through funnel-shaped depressions with actively slumping clay and till banks, to sporadic depressions in which the underlying bedrock is exposed in ledges or small shelves opening to cavities in the bedrock below (Fig. GS-19-17). Clay and till veneers in the floors of the depressions range up to 3 m in thickness, but many were observed to be less than 1 m. This is in marked contrast to the bare dolomite pavement that prevails over much of the region.

Periodic ponding of water (especially in early spring and during storm overload situations) is also evidenced by rapid changes in water levels observed in some caves (4 m in two weeks), as well as relict "scum lines" recording peak levels 5 m above the dry cave floors (**Moosearm Pit**, in *Sweet et al.*, 1988).

At the outflow points along the base of the Silurian escarpment similar evidence is seen of periodic fluctuations in drainage rates and flows. Exsurgent springs (Jennings, 1985) form a continuous and prolific series of drainage points from Grand Rapids north to Williams River. Most represent groundwater seepage zones (10-200 m wide) scattered along the foot of the escarpment 20-30 m below the base of the persistent cliffs of the Moose Lake Formation (see Bannatyne, 1988). Locally the flow is concentrated into prominent brooks 1-3 m wide, with dolomite shingle-lined beds, crossing local subround (10-40 m wide) fen-pools and outwash pans, also lined with dolomite shingle and marly mud. Dry channels and runnels emerging up to 10 m above the June level of seepage and flow, point to periodic overloads that are in keeping with the complementary surges interpreted in the lakes, sinks and caves of the upland plateau.

All springs observed thus far at the base of the escarpment have been diffuse, or weakly channeled upwellings from thickly vegetated hillsides, the immediate foundations of which appear to be beach shingle rather than bedrock. This constant association of bedrock escarpment and masking sub- parallel Agassiz beach ridges may mean that most emergence points are choked with dolomite shingle, making them inaccessible without some degree of excavation.

The relatively stable and continuous nature of the dendritic drainage system on the coastal plain, with sinuous meandering channels that hold their water throughout the ice-free season, points either to an even and widespread veneer of impermeable clays throughout this region, or to a water table in the uplands whose saturation surface lies close to or above the elevation of the coastal plain.

It seems possible that the uplands were once covered with lacustrine clay and till and that much of this was removed during the late shoaling stages of Lake Agassiz, and redeposited into the karst depressions on the plateau, or onto the coastal plain. This would have laid bare the Silurian bedrock on the uplands thereby facilitating percolation in this region in contrast to surface drainage across the coastal plain.

Further work is planned to obtain accurate elevations on the exsurgent points to see whether they are consistently at the same stratigraphic level or whether they are regionally discordant and controlled by a relatively constant water table. Drill logs from holes to the west (Bezys, report GS- 20, this volume) suggest that impermeable beds (argillaceous dolomite) may exist in the Stonewall or Stony Mountain Formations close to the contact of the Ordovician and Silurian. If this is the case then the points of emergence may well be related to an aquitard in the dolomites, that constrains the relatively robust flow of the subsurface waters, creating the springs at the base of the escarpment (Fig. GS-19-18).

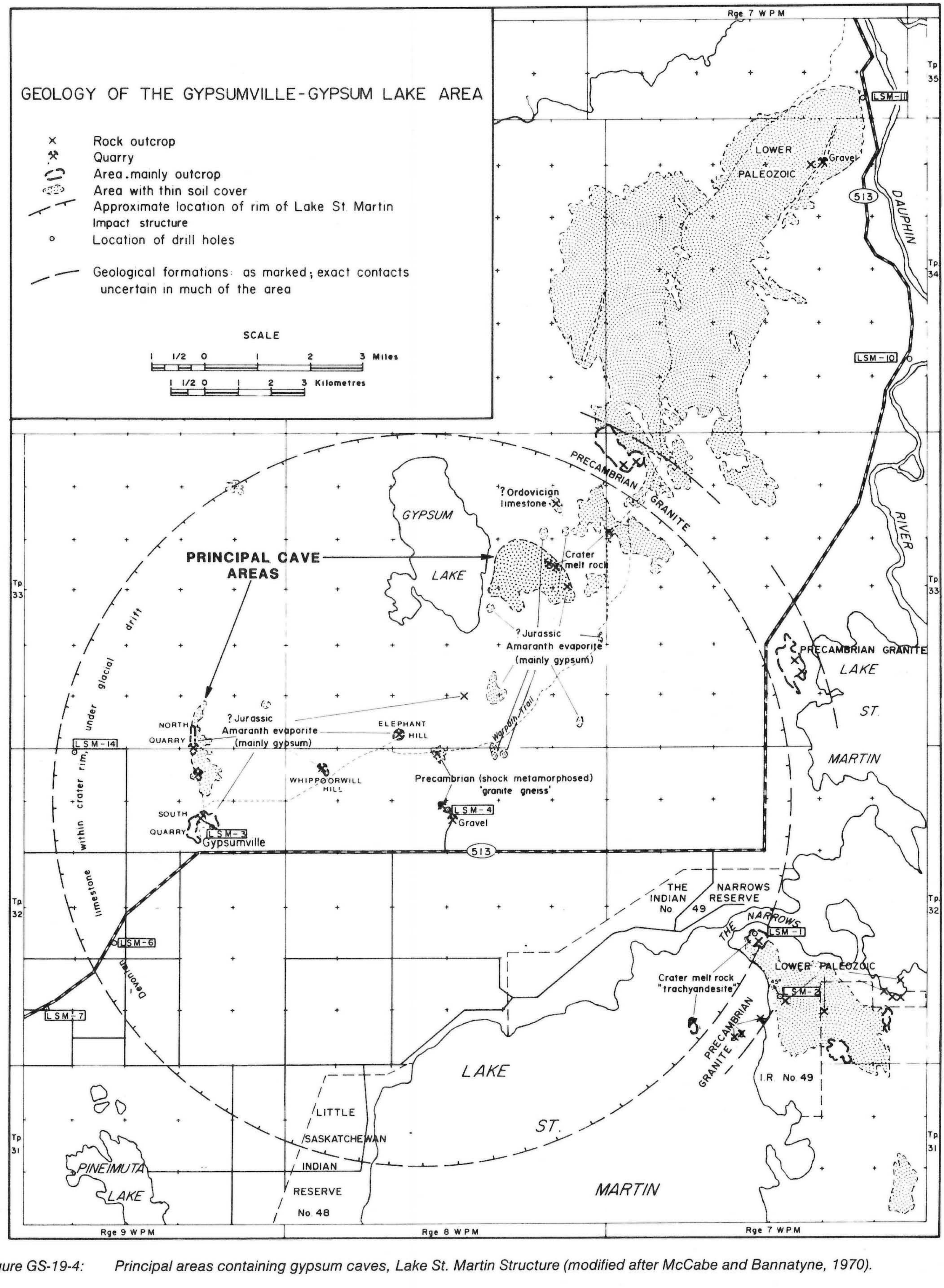

Figure GS-19-4: Principal areas containing gypsum caves, Lake St. Martin Structure (modified after McCabe and Bannatyne, 1970).

Figure GS-19-5: *Main chamber of Stormcloud Cave, east of Gypsum Lake.*

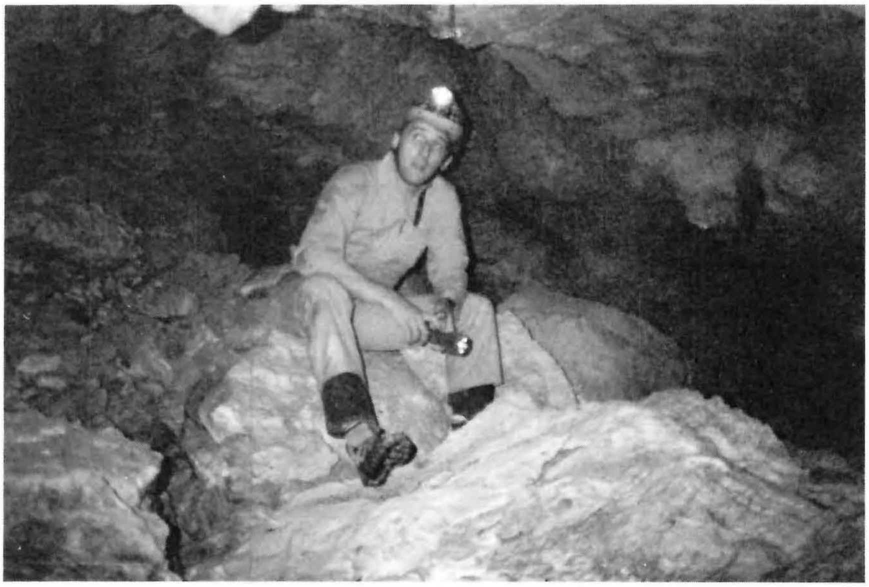

Figure GS-19-6: *Negotiating the first bend in Zig-zag Cave. Note solution pockets in ceiling.*

Figure GS-19-7: *Phreatic tube (The Subway) in Labyrinth Cave, east of Gypsum Lake. Height 50 cm.*

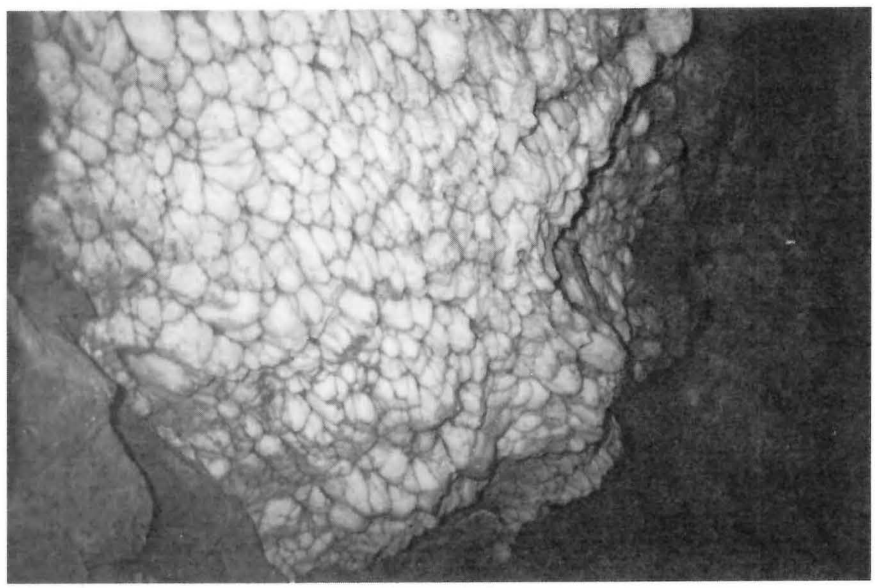

Figure GS-19-8: *Chicken net texture in ceiling of Stormcloud Cave, east of Gypsum Lake.*

Figure GS-19-10: *Asymmetrical folds in gypsum layers within Labyrinth Cave.*

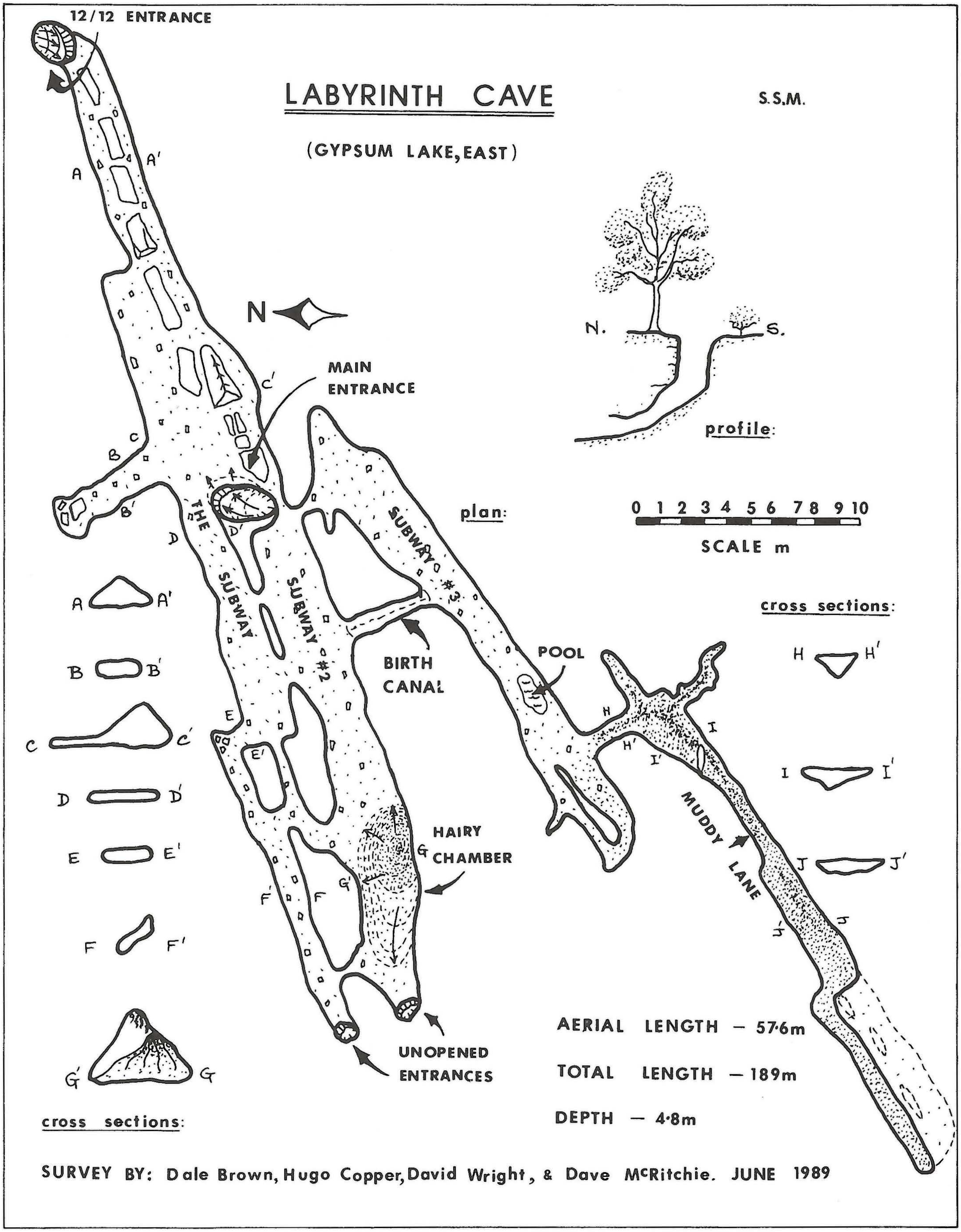

Figure GS-19-9: Labyrinth Cave (map), east of Gypsum Lake.

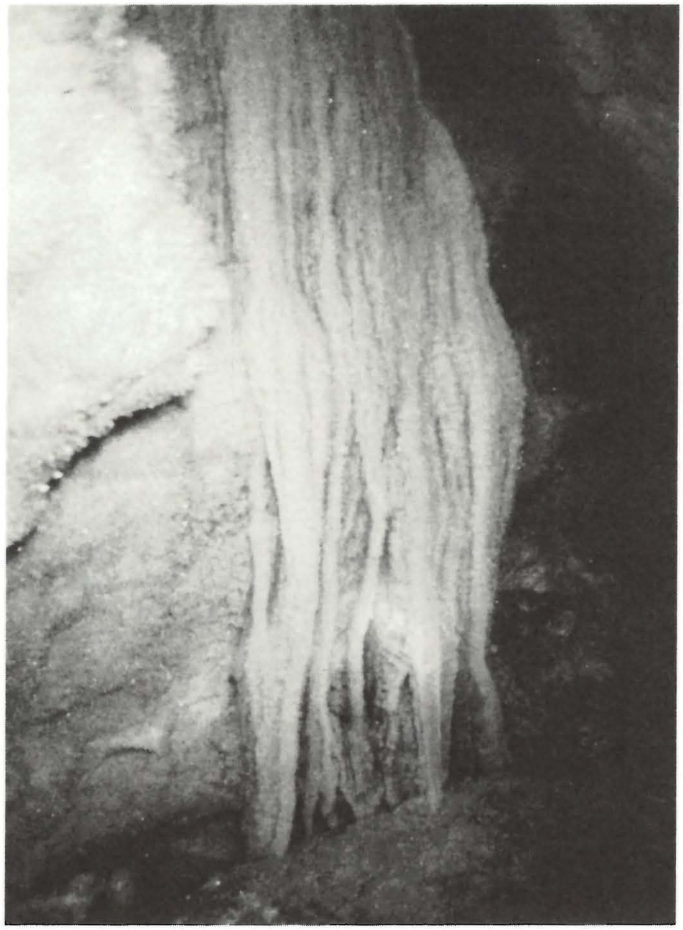

Figure GS-19-11: Crenellated ice flowstone waterfall in Crystal Palace crawlway, east of Gypsum Lake.

Figure GS-19-12: Euhedral, hexagonal ice crystals and pendants in Octopus Cave similar to those in Crystal Palace, east of Gypsum Lake. (Photo Dave Fox, SSM).

Figure GS-19-13: Breakdown blocks and ice crystals leading to inner chamber of Crystal Palace. (Photo J. Rawluk, SSM.)

ADDENDUM

In late October, close to 40 additional cave entrances were discovered in gypsum bedrock during exploratory traverses south and east of Gypsum Lake.

In most respects the caves resemble, in size and geometry, those described in the "north quarry" and "Labyrinth" areas. However, the maze of interconnecting corridors in the Catacombs south of Gypsum Lake, promises to yield passage lengths far in excess of the 189 m measured in Labyrinth; and Fold Cavern near the northern limit of the gypsum outcrop belt exhibits the highest (3 m) and most spacious chamber yet observed in the region as well as the greatest depth of room development below the surface (8-9 m).

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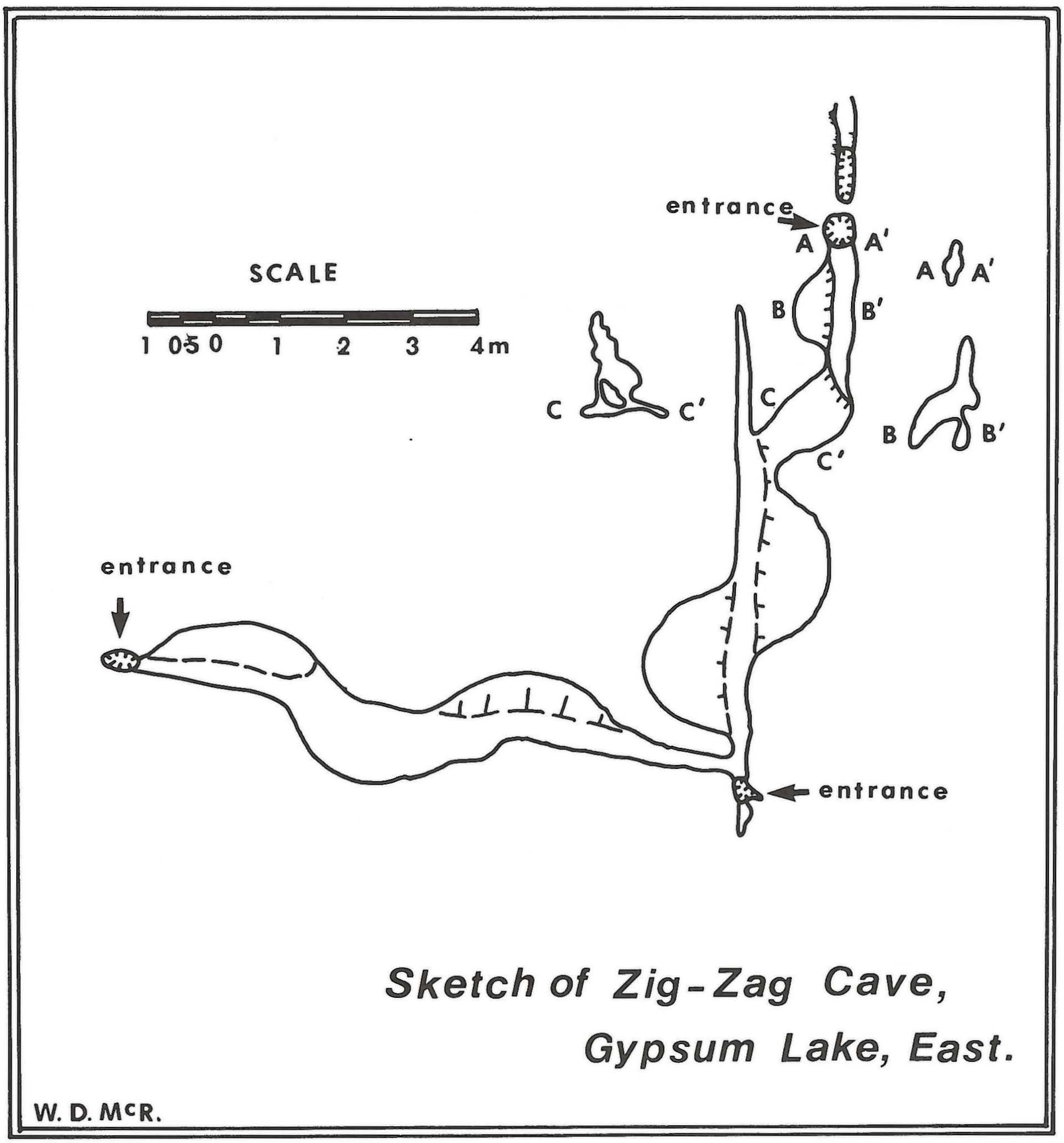

Figure GS-19-14a: Sketch map of Zig-zag Cave, east of Gypsum Lake.

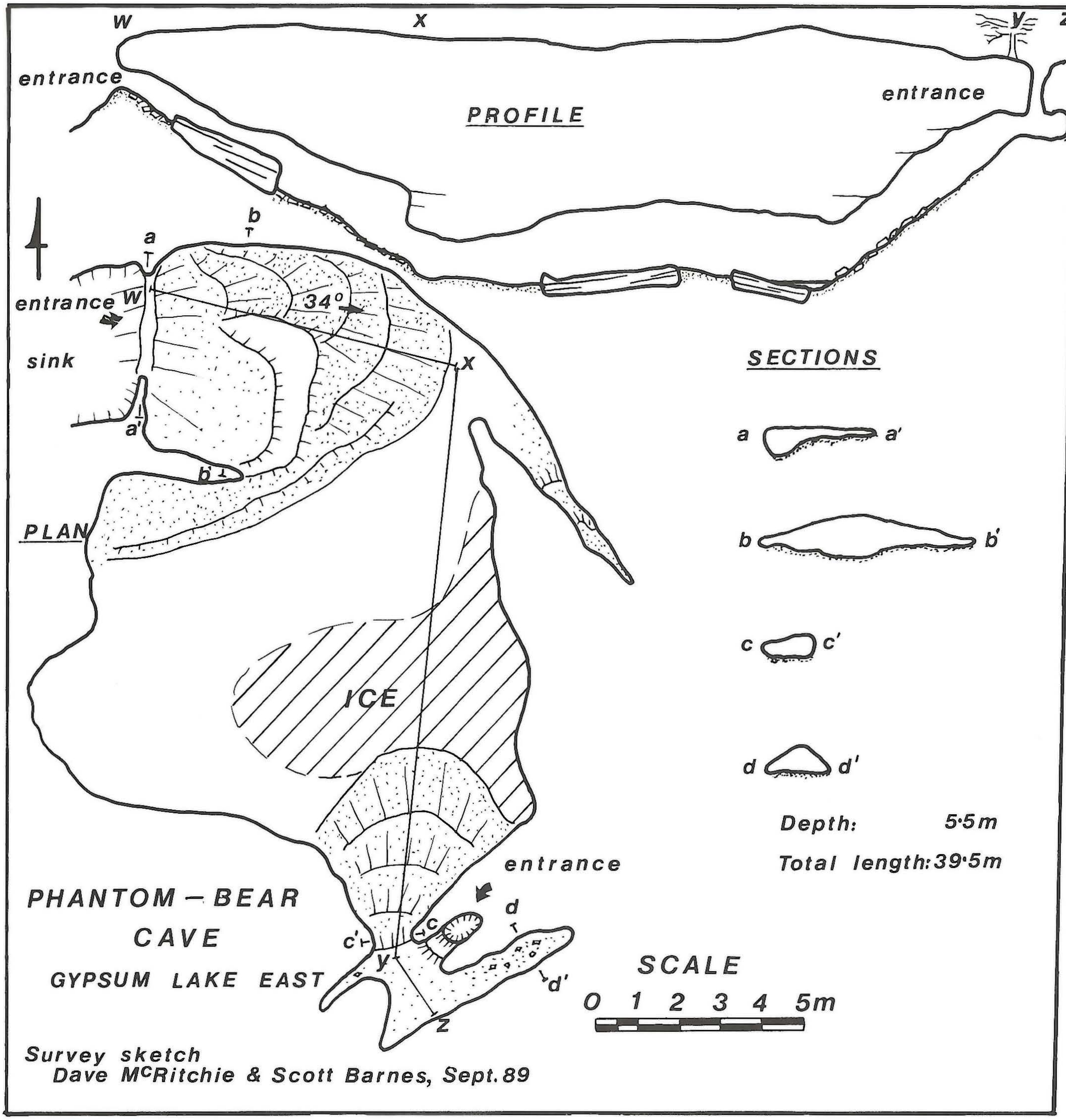

Figure GS-19-14b: Sketch map of Phantom-Beaver Cave, east of Gypsum Lake.

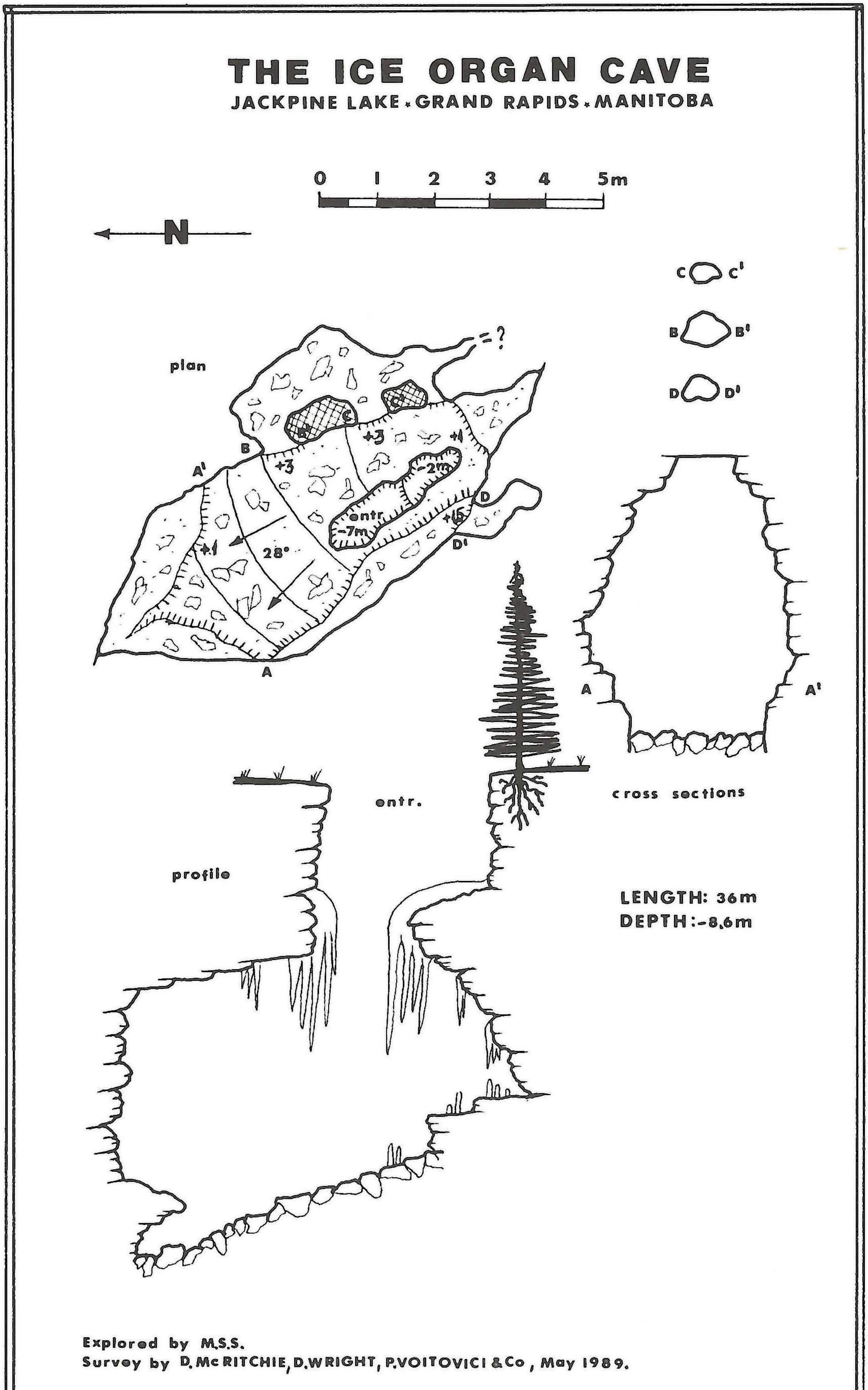

Figure GS-19-15a: Map of Ice-organ Cave, southwest of Jackpine Lake, Grand Rapids Uplands.

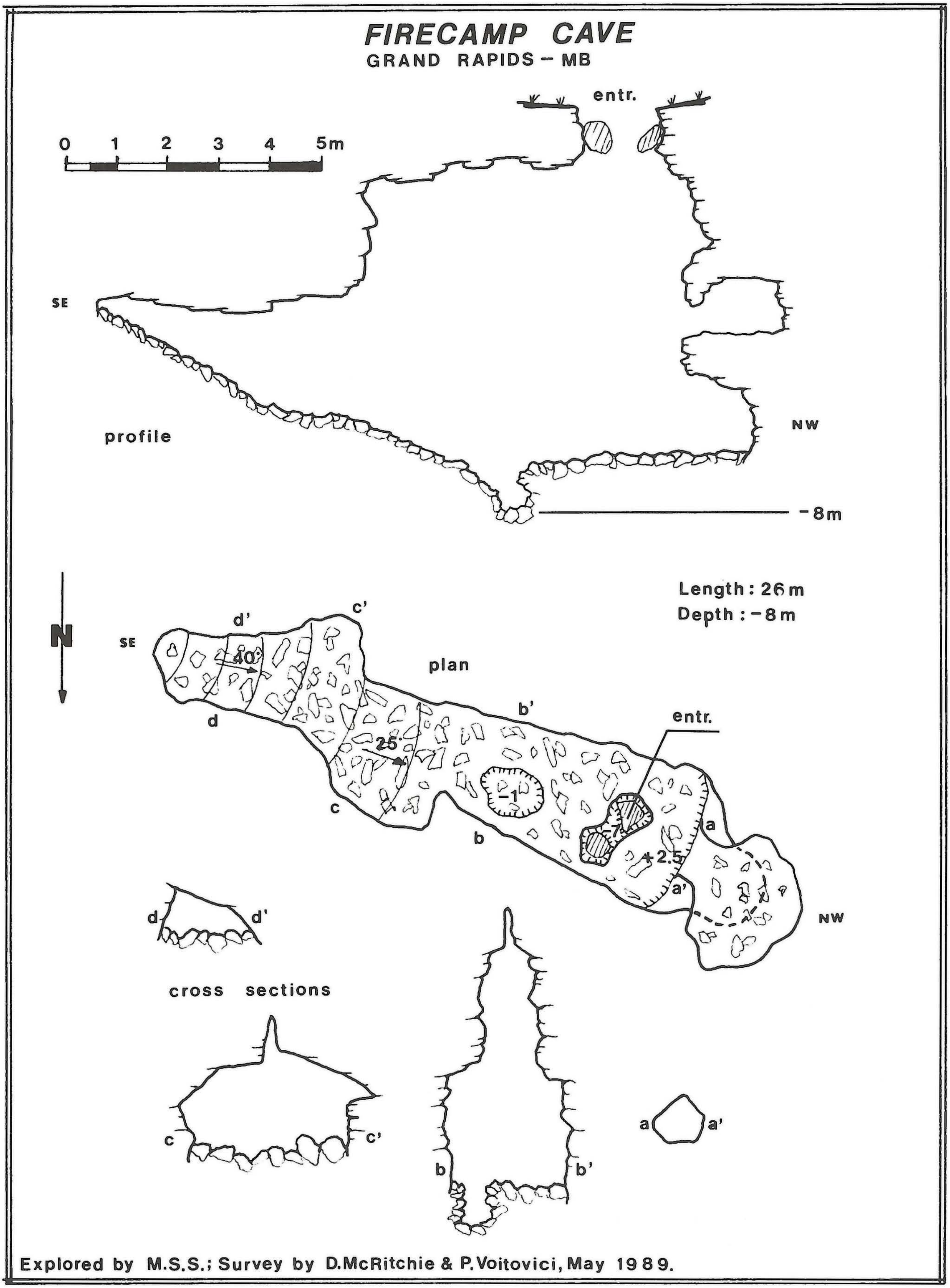

Figure GS-19-15b: Map of Firecamp Cave, Grand Rapids Uplands.

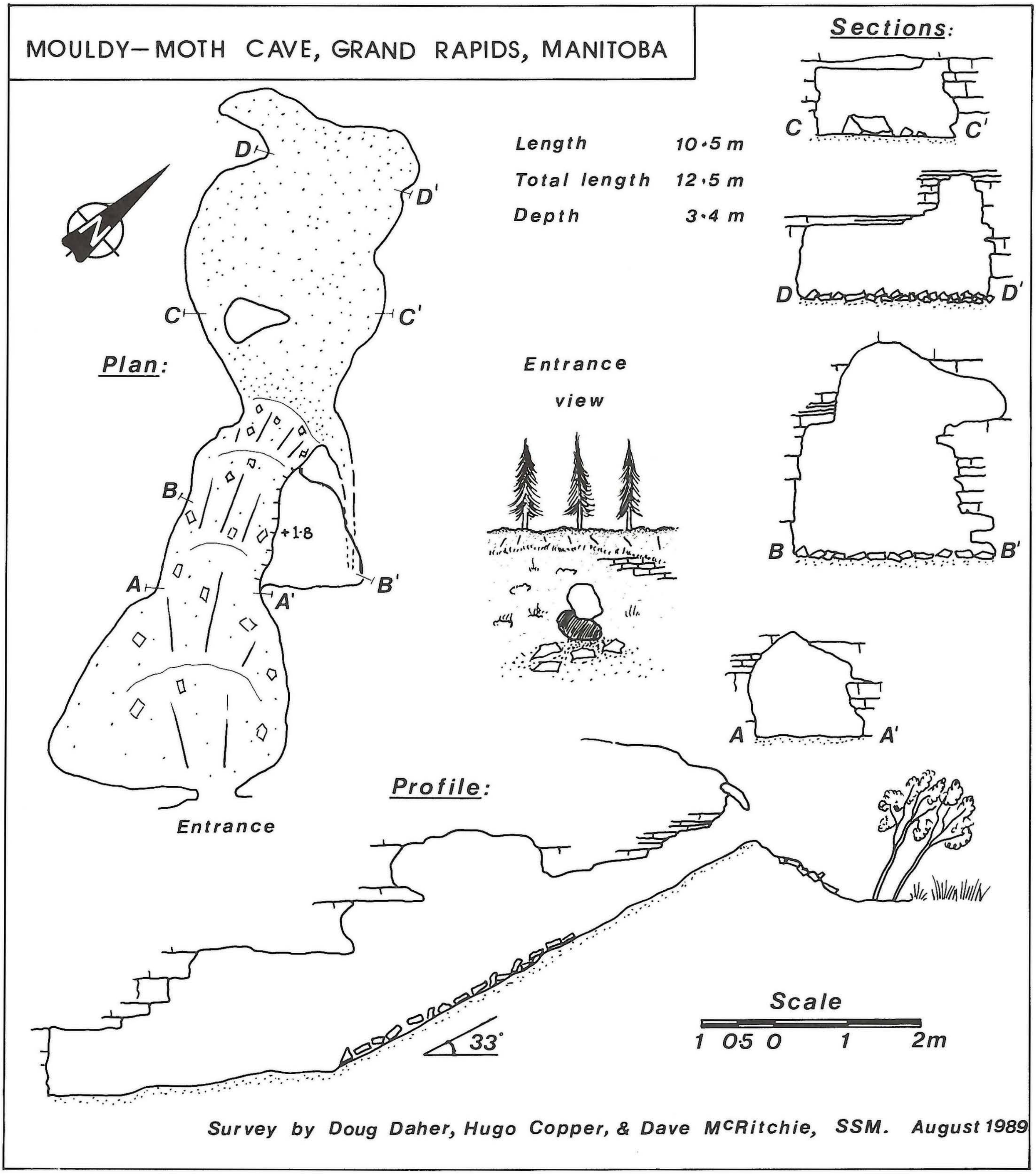

Figure GS-19-16a: Map of Mouldy-Moth Cave, Grand Rapids Uplands.

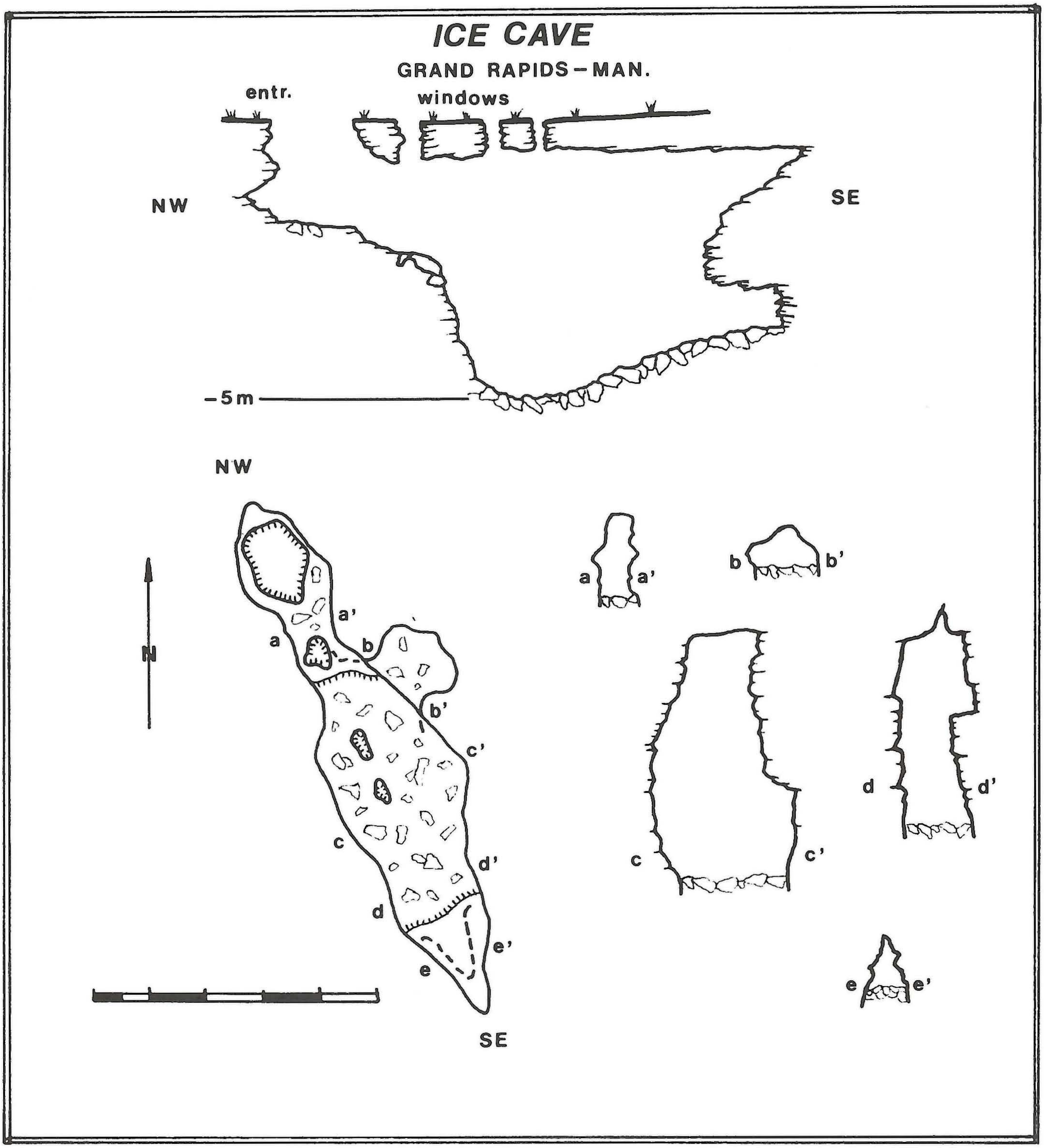

Figure GS-19-16b: Map of Ice Cave, Grand Rapids Uplands.

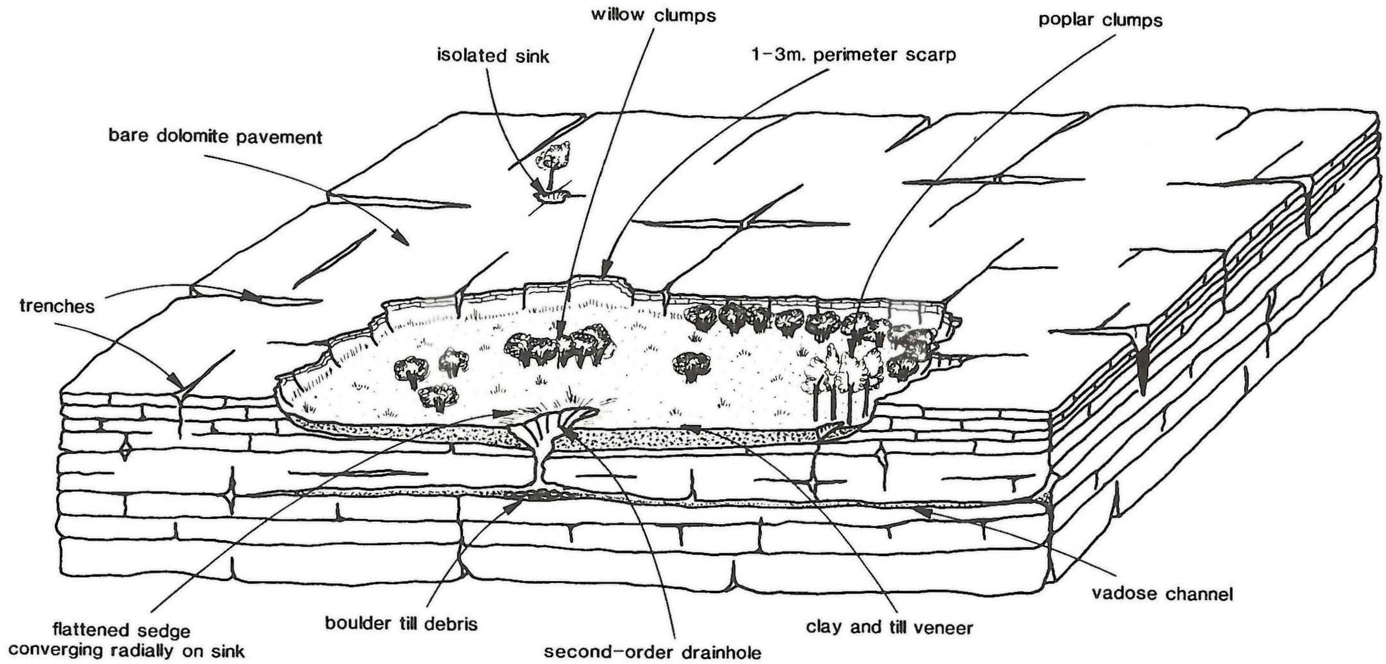

Figure GS-19-17: *Sketch of regional depression and secondary drain hole together with associated features common in the Grand Rapids Uplands.*

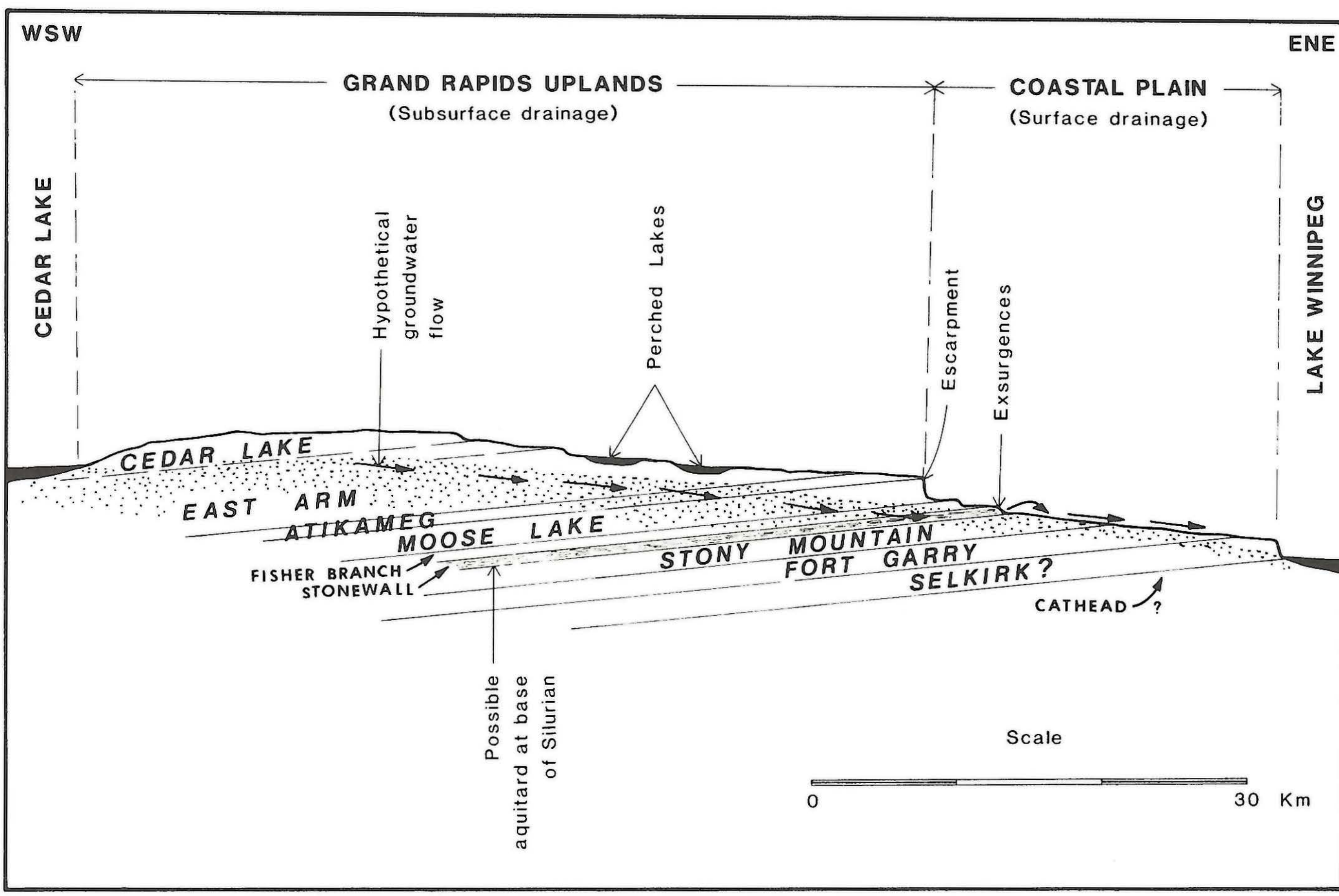

Figure GS-19-18: *Possible groundwater configuration, Grand Rapids Uplands and neighbouring coastal plain.*

GS-20 STRATIGRAPHIC AND INDUSTRIAL MINERALS CORE HOLE PROGRAM

by R.K. Bezys

Bezys, R.K. 1989: Stratigraphic and industrial minerals core hole program; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

Stratigraphic studies continued in the Grand Rapids area where seven core holes totalling 791.5 m were drilled (five deep, two shallow) (Fig. GS-20-1). Three industrial mineral holes (one deep, two shallow) were drilled on the west shore of Swan Lake to delineate a subsurface breccia zone for possible Pb-Zn mineralization. A total of 134.8 m of core were drilled within a 25 to 50 m radius of a previous stratigraphic core hole (M-7-78) that encountered a breccia zone.

Industrial mineral investigations were carried out near Seymourville, on the east shore of Lake Winnipeg, to investigate kaolin and silica sand deposits in the Winnipeg Formation. Two Precambrian sites near Cross Lake were cored to test joint patterns in a black granite unit (M-7A-89 and M- 7B-89) and M-6-89 was drilled at Pipestone Lake to examine a chromitiferous dunite. Table GS-20-1 summarizes the lithologies encountered in these core holes. All drill data and core are available for examination.

GRAND RAPIDS CORE HOLE PROGRAM

Seven stratigraphic core holes, located north of Grand Rapids (Fig. GS-20-1), were drilled primarily to provide new Silurian lithofacies data in areas of poor outcrop and subsurface control. Five deep core holes were drilled to the top of the Ordovician Winnipeg Formation, but no attempts were made to reach the Precambrian basement because of the potential problems in drilling through unconsolidated sandstone beds of the Winnipeg Formation. Two of the holes, M- 3-89 and M-4-89, were collared in the Silurian Cedar Lake Formation and continued downward to include the entire Silurian and Ordovician sequence. The three other deep core holes, M-1-89, M-2-89, and M-5-89, commenced in the Silurian East Arm Formation, and thus do not include the uppermost Cedar Lake Formation. Shallow stratigraphic holes M-3A-89 and M-5A-89 were drilled west of their deeper counterparts to intersect a thicker portion of the Cedar Lake Formation.

Table GS-20-1 presents the formation tops picked from these stratigraphic core holes. Marker beds typically seen in Silurian outcrops were not clearly defined in the core holes and therefore were not picked. This may represent actual omissions of the marker beds in this area of subcrop, or the unconsolidated nature of these markers (sands and clays) did not show up in the core. The Silurian/Ordovician marker bed "T" was difficult to define in the Stonewall Formation. Thus, the System boundary was not identified in these holes and is pending compilation of all available outcrop and core hole data from the area.

No definite cave or cavity development was encountered in the Silurian core hole sequence, but a possible solution cavity was discovered in M-1-89 where approximately 5.3 m of core was lost in the Lower Stony Mountain Formation (Ordovician) at 83.9 m.

WEST SHORE OF SWAN LAKE

Holes M-8-89, M-9-89, and M-10-89 were drilled on the west shore of Swan Lake, immediately southwest of several Devonian outcrops of the Souris River and Dawson Bay Formations. An earlier hole, M-7-78, was drilled in the same area to determine reef thickness in the Winnipegosis Formation and to clarify correlations of Upper Devonian strata. Instead of a normal sequence of Souris River/Dawson Bay strata, 88.9 m of monomict and polymict dolomite - shale - limestone breccia overlying a "normal" inter-reef Winnipegosis sequence was encountered in M-7-78 (McCabe, 1978).

The site was redrilled this year for industrial mineral purposes to delineate the subsurface extent of the breccia zone for possible Pb-Zn mineralization. Hole M-9-89, drilled within 50 m of M-7-78, did not intersect this breccia zone. Instead, it encountered a somewhat typical sequence of Souris River/Dawson Bay strata (Table GS-20-1). The Transition Beds and portions of the Second Red Beds appear to be somewhat more brecciated than normal Souris River/Dawson Bay strata farther north in the section. Further compilation work will be required to attempt correlation of these two holes. Two shallow holes, M-8-89 and M-10-89, encountered only the Upper Point Wilkins Member of the Souris River Formation.

SEYMOURVILLE

Holes M-11-89 to M-17-89 were drilled on the east side of Lake Winnipeg as part of an industrial mineral investigation to determine the subsurface extent of kaolin and silica sand deposits in the Winnipeg Formation. The lithologies encountered in these holes consist of glaciolacustrine clays and bouldery tills, poorly consolidated quartzose sandstone (Winnipeg Formation), and highly weathered Precambrian basement rocks. These consist of weathered chlorite schists, blue-green to white kaolin, and altered granitoid rocks. Holes M-11-89 and M-15-89 contained considerable thicknesses of Winnipeg sandstone compared to the other holes (20.3 and 17.8 m, respectively).

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1978: Stratigraphic Core Hole and Mapping Programme; **in** Manitoba Mines, Resources and Environmental Management, Mineral Resources Division, Report of Field Activities, 1978, p. 64-67.

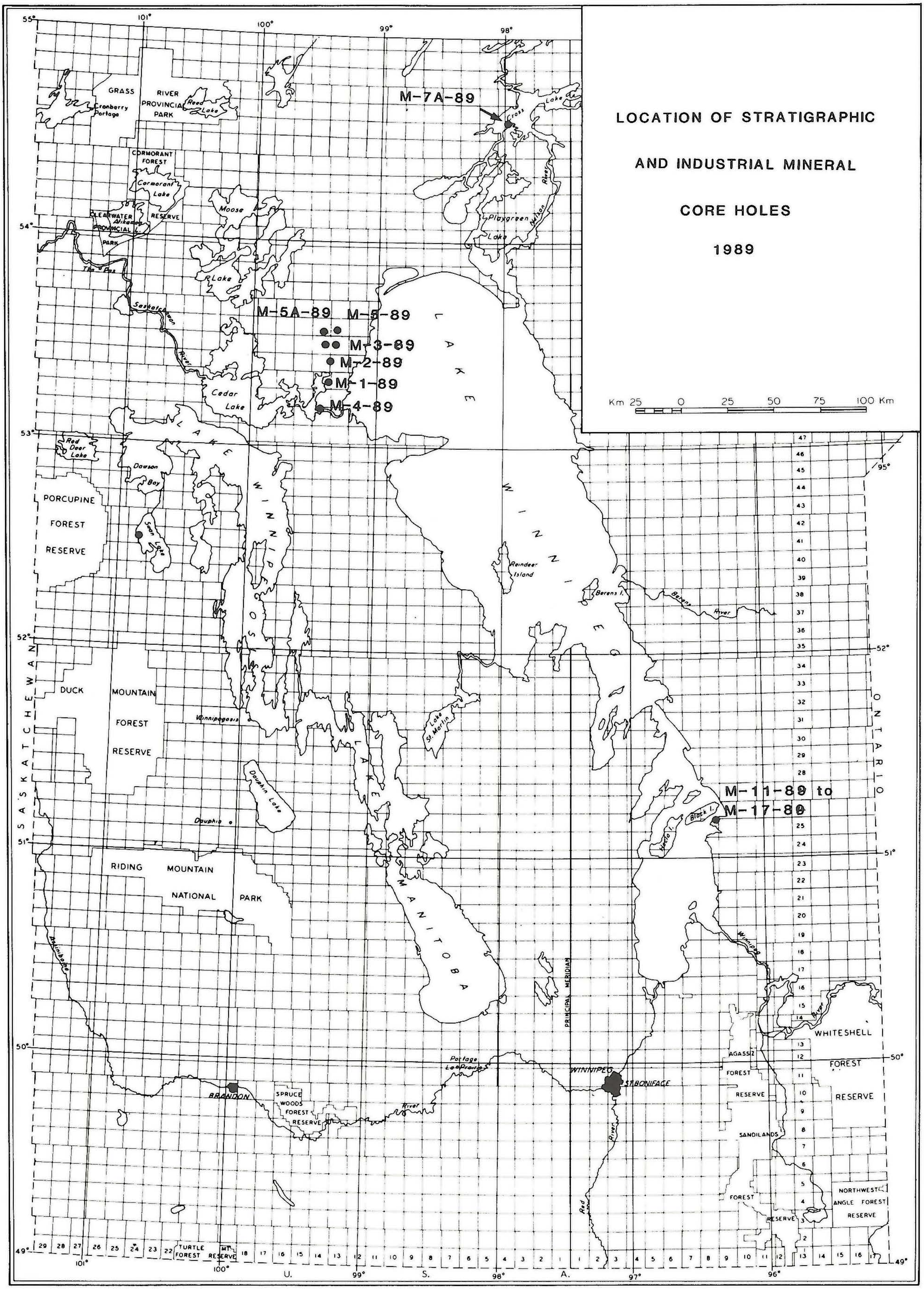

Figure GS-20-1: *Location of 1989 stratigraphic and industrial mineral core holes in Manitoba. See Table GS-20-1 for coordinates and elevations.*

TABLE GS-20-1

Hole No.	Location and Elevation	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
M-1-89 Footprint L.	8-7-50-13W +260.6	SILURIAN-East Arm	0.0-4.26	Dolomite, grey, dense, massive, very fine to fine crystalline, calcarenaceous with sandy zones.
		Atikameg	4.26-8.84	Dolomite, buff, porous, fine to medium crystalline, slightly granular.
		Moose Lake	8.84-21.91	Dolomite, grey, dense, medium to massive bedded, fine crystalline, floating sand grains in one horizon, stromatolitic in places.
		Fisher Branch	21.91-29.95	Dolomite, light brown to yellow, very fine to fine crystalline, vuggy, *Virgiana* fossils.
		SILURIAN/ORDOVICIAN Stonewall	29.95-34.1	Dolomite, tan to white, fine crystalline, faintly laminated.
			34.1-36.2	Dolomite, grey, argillaceous, very dark grey in places, mottled.
			36.2-54.4	Dolomite, off-white to yellow, irregular appearance, vuggy, fossiliferous, some mottling in places.
		ORDOVICIAN - Upper Stony Mountain	54.4-68.26	Dolomite, tan, mottled, fine crystalline, massive, dense, some bituminous partings.
		Lower Stony Mountain	68.26-98.46	Dolomite, massive, grey to tan, interbedded with argillaceous dolomite, good mottling and nodular development at top, fine to medium crystalline, possible cavity at 83.95 m.
		Upper Red River	98.46-103.31	Dolomite, grey to light grey, distinctly mottled, fine to medium crystalline, massive.
		Lower Red River	103.31-145.91	Dolomite, tan to light brown, massive, faint nodular appearance, fine to medium crystalline, lower 30 cm - mixed dolomite and sand lithologies.
		Winnipeg	145.91-148.25	Sandstone, argillaceous, grey, medium grained, massive, scattered pyrite blebs.
M-2-89 10 Mile Road	12-19-51-31W +274.3	SILURIAN-East Arm	0.0-8.24	Dolomite, grey, dense, very fine to fine crystalline, scattered floating sand grains, faint laminations.
		Atikameg	8.24-14.07	Dolomite, buff, porous, medium crystalline, reefal-like.
		Moose Lake	14.07-26.82	Dolomite, tan-white, massive, stromatolitic in places, some bioclastic material, scattered floating sand grains.
		Fisher Branch	26.82-34.57	Dolomite, tan to white, fine crystalline, massive, some nodular development, rare coral fragments.
		SILURIAN/ORDOVICIAN Stonewall	34.57-38.34	Dolomite, brown, massive, faintly laminated, fine crystalline, slightly argillaceous.
			38.34-40.32	Dolomite, dark grey, argillaceous, massive.
			40.32-56.85	Dolomite, tan, massive, faintly laminated, some argillaceous nodules, thin- bedded, fine crystalline, abundant kaolinite? clasts towards the base.
		Upper Stony Mountain	56.85-71.78	Dolomite, tan to light brown, massive, fine crystalline, nodular.
		Lower Stony Mountain	71.78-102.5	Dolomite, light brown with some argillaceous beds, dense and massive, fine crystalline, faint mottling.
		Red River (undifferentiated)	102.5-147.99	Dolomite, tan to light brown, fine to medium crystalline, indistinct mottling - better at top, some fossil solutioning, scattered vugs.
		Winnipeg	147.99-151.4	Sandstone, dark green to grey, argillaceous, fine to medium grained, mottled appearance.
M-3-89 Cattrail	3-17-52-13W +274.3	SILURIAN-Cedar Lake?	0.0-3.15	Dolomite, buff to light brown, very finely crystalline, some fossil solutioning.
		East Arm	3.15-13.75	Dolomite, light grey, dense, very fine to fine crystalline, scattered floating sand grains, massive.
		Atikameg	13.75-17.98	Dolomite, buff, porous, fine to medium crystalline, some fossil solutioning, massive.

TABLE GS-20-1

Hole No.	Location and Elevation	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
		Upper Moose Lake	17.98-27.62	Dolomite, tan to grey, very fine to fine crystalline, wispy laminations, minor kaolinite clasts.
		Lower Moose Lake	27.62-33.0	Dolomite, tan to buff, minor clay beds, fine to medium crystalline, some nodular-like argillaceous zones.
		Fisher Branch	33.0-42.0	Dolomite, brown to tan, dense, very fine to fine crystalline (lithographic), scattered *Virgiana* fossils.
		SILURIAN/ORDOVICIAN Stonewall	42.0-44.55	Dolomite, light tan, dense, argillaceous beds in places, fine to medium crystalline, rare kaolinite clasts.
			44.55-53.6	Dolomite, grey to yellow, dense, medium crystalline, healed calcite fractures, minor brecciation.
			53.6-61.04	Dolomite, light brown to white, dense, faint nodules, some burrow mottling.
		Upper Stony Mountain	61.04-	Dolomite, tan to buff, dense, fine crystalline.
			64.5-73.9	Dolomite, nodular, tan, faintly laminated.
			73.9-78.0	Dolomite, well-developed nodules, brown to tan, vuggy.
			78.0-90.92	Dolomite, nodular, tan, vuggy, rare vugs with sulphide blebs.
		Lower Stony Mountain	90.92-101.19	Dolomite, grey, dense, very fine to fine crystalline, slightly mottled, vuggy in places.
		Upper Red River	101.19-109.3	Dolomite, tan to grey, mottled, fine crystalline.
		Lower Red River	109.3-149.5	Dolomite, tan to brown, dense, some mottling and fossil solutioning, argillaceous towards base.
		Winnipeg	149.5-151.3	Sandstone, grey, argillaceous, mottled, some sulphide mineralization.
M-3A-89 Cattrail W.	8-13-52-14W +273.7	SILURIAN-Cedar Lake	0.0-8.61	Dolomite, tan to white, dense, very fine crystalline, minor breccia zone, stromatolitic, bioclastic zone at 5.1 m with *favosites* fragment.
		East Arm?	8.61-9.95	Dolomite, brown, very fine to fine crystalline, calcarenaceous at top, vuggy in places.
M-4-89 Capstan Pt.	5-34-48-14W +253.0	SILURIAN-Cedar Lake	0.0-14.1	Dolomite, buff to brown, very fine to medium crystalline, stromatolitic in places, rare fossils (coral fragments), dense and massive.
		East Arm	14.1-22.27	Dolomite, yellow to grey, dense, very fine to fine crystalline (lithographic), stromatolitic laminations, argillaceous in places, rare sandy zones.
		Atikameg	22.27-27.05	Dolomite, buff to tan, vuggy, fine to medium crystalline, some mottling.
		Upper Moose Lake	27.05-30.60	Dolomite, tan, very fine to fine crystalline, lithographic, massive.
		Lower Moose Lake	30.60-37.60	Dolomite, light brown to off-white, fine to medium crystalline, scattered floating sand grains, at 33.32 m possible *Virgiana* fragments.
		Fisher Branch	37.60-47.17	Dolomite, tan to white, porous, fine crystalline, some calcarenaceous zones, fossiliferous with coral fragments and *Virgiana*.
		SILURIAN/ORDOVICIAN Stonewall	47.17-69.46	Dolomite, grey to tan, very fine to fine crystalline, argillaceous zones in places, slight mottling, vugs increasing toward base.
		Upper Stony Mountain	69.46-89.36	Dolomite, tan to dark brown, argillaceous, faint nodular appearance, fine crystalline, massive.
		Lower Stony Mountain	89.36-119.34	Dolomite, brown, fine crystalline, mottled to nodular, argillaceous to calcarenaceous in places, dense, massive.
		Upper Red River	119.34-125.19	Dolomite, tan to grey, mottled, fine crystalline.
		Lower Red River	125.19-167.4	Dolomite, tan to brown, mottled to nodular, fine to medium crystalline, granular.
		Winnipeg	167.4-169.65	Sandstone, brown to grey, argillaceous, very fine to fine grained, mottled.

TABLE GS-20-1

Hole No.	Location and Elevation	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
M-5-89 Microwave Road	14-10-53-13W +289.6	SILURIAN-East Arm	0.0-12.52	Dolomite, buff, dense, very fine to finely crystalline, scattered floating sand grains.
		Atikameg	12.52-16.79	Dolomite, buff, massive, fine to medium crystalline, rare floating sand grains, very porous.
		Moose Lake	16.79-28.15	Dolomite, tan to buff, dense, massive, faintly mottled, scattered sand grains, fine to medium crystalline.
		Fisher Branch	28.15-38.36	Dolomite, brown, fine to medium crystalline, slightly porous, *Virgiana* fossils, some vugs.
		SILURIAN/ORDOVICIAN Stonewall	38.36-41.6	Dolomite, tan, dense, faintly laminated, rare fossil debris, fine to medium crystalline.
			41.6-43.06	Interbedded argillaceous dolomite and dense dolomite, fine crystalline, mottled, massive.
			43.06-51.19	Dolomite, tan to buff, vuggy, cherty, fine to medium crystalline.
			51.19-56.85	Dolomite, tan, argillaceous, distinctly mottled, fine to medium crystalline, fossiliferous.
			56.85-59.75	Dolomite, grey to brown, dense, very fine to fine crystalline, mottled.
		Upper Stony Mountain	59.75-89.1	Dolomite, tan, nodular, fine crystalline, massive.
		Lower Stony Mountain	89.1-101.06	Dolomite, grey to tan, argillaceous, very fine to fine crystalline, slight burrow mottling.
		Red River (undifferentiated)	101.06-146.99	Dolomite, tan, very fine to fine crystalline, granular, vuggy, faintly nodular and laminated, mottling more distinct at top, massive.
		Winnipeg	146.99-148.55	Sandstone, grey, argillaceous, fine to medium grained.
M-5A-89 Microwave Road West	14-10-53-14W +282.5	SILURIAN-Cedar Lake	0.0-11.28	Dolomite, buff to brown, dense, massive, very fine crystalline.
		East Arm	11.28-12.5	Dolomite, buff, very fine to fine crystalline, prominent sandy dolomite beds up to 10 cm thick.
M-6-89 Pipestone L. 45°S	6042560N 581860E +205.0	PRECAMBRIAN	0.0-59.3	Chromitiferous Dunite.
M-7A-89 Jenpeg Causeway	6041125N 565575E +220.0	PRECAMBRIAN	0.0-8.5	Diabase
M-7B-89 Jenpeg Causeway	6041125N 565575E +220.0	PRECAMBRIAN	0.0-10.0	Diabase
M-8-89 Bellsite #1	2-21-41-24W +259.0	Overburden	0.0-0.6	Bouldery till
		DEVONIAN-Souris R. (Point Wilkins)	0.6-20.35	Limestone, tan, microcrystalline (lithographic), stylolitic, scattered fossil fragments (gastropods and brachiopods), rare argillaceous zones, slight brecciation in places, medium bedded.
M-9-89 Bellsite #2	2-21-41-24W +259.0	DEVONIAN-Souris R. (Upper Point Wilkins)	0.0-33.97	Limestone, brown to tan, massive, dense, very fine to fine crystalline, very stylolitic with argillaceous partings, slight brecciated zones, scattered brachiopod fossils, rare oncolites.
		(Lower Point Wilkins)	33.97-40.39	Limestone, grey to red-grey, argillaceous, slightly nodular appearance, fossiliferous (brachiopods and crinoids), very fine crystalline, massive.
		(First Red Beds)	40.39-49.39	Calcareous and non-calcareous shales and breccia, red to green, fine to medium grained, interbeds of grey dolomite and dolomitic limestone.
		Upper Dawson Bay (Member D)	49.39-59.54	Limestone, brown to grey, granular, massive to porous, fine to medium crystalline, mottled in places, scattered fossil-rich zones (brachiopods), slightly stylolitic.

TABLE GS-20-1

Hole No.	Location and Elevation	SYSTEM/Formation/ (Member)	Interval (m)	Summary Lithology
		Middle Dawson Bay (Member C)	59.54-76.69	Argillaceous, fossiliferous limestone, blue-grey to green, fine to medium crystalline.
		Lower Dawson Bay (Member B)	76.69-83.64	Limestone, fossiliferous, grey to yellow, argillaceous in places, fine crystalline.
		Dawson Bay (Second Red Beds)	83.64-93.6	Argillaceous limestone breccias and shales, red to green-grey, interbeds of limestone and dolomite, extremely brecciated, medium grained.
		Transitional Beds	93.6-101.9	Interbedded argillaceous calcareous dolomite, porous limestone, and laminated argillaceous limestone, fine to medium crystalline, extremely brecciated in places, stylolitic in places.
		Winnipegosis	101.9-102.8	Limestone, finely laminated (stromatolitic), buff to brown, reef-like in places, fine crystalline.
M-10-89 Bellsite #3	2-21-41-24W +259.0	Overburden	0.0-0.10	Bouldery till.
		DEVONIAN-Souris R. (Point Wilkins)	0.10-11.59	Limestone, tan to white, stylolitic, microcrystalline, massive, scattered fossil fragments (brachiopods and gastropods).
M-11-89 Seymourville	16-25-25-8E +250	Overburden	0.0-2.5	Bouldery till.
		ORDOVICIAN-Winnipeg	2.5-6.79	Sandstone, yellow, clayey, fine grained.
			6.79-22.75	Sandstone, grey to white, fine to medium grained.
		PRECAMBRIAN	22.75-23.5	Kaolinitic clay, blue-grey to white (weathered basement rocks?).
M-12-89 Seymourville	9-31-25-9E +240	Overburden	0.0-9.1	Glaciolacustrine clays and silts, dark brown.
		ORDOVICIAN-Winnipeg to PRECAMBRIAN	9.1-12.19	Unconsolidated sands (at top), blue-grey to white kaolin, lower 0.5 m - weathered chlorite schist.
M-13-89 Seymourville	1-31-25-9E +240	Overburden	0.0-3.8	Lost core.
			3.8-8.89	Glaciolacustrine clays, dark grey.
		ORDOVICIAN-Winnipeg?	8.89-13.45	Lost core (probably Winnipeg sands).
		PRECAMBRIAN-weathered basement	13.45-15.52	Unconsolidated sands, weathered schists and granitoids?, some iron staining, fine to medium grained.
M-14-89 Seymourville	3-36-25-8E +240	Overburden	0.0-18.0	Recent sands and bouldery tills.
M-15-89 Seymourville	11-25-25-8E +250	Overburden	0.0-6.7	Bouldery till and glaciolacustrine clays, grey to brown.
		ORDOVICIAN-Winnipeg	6.7-24.5	Sandstones, interbedded light grey to black, argillaceous in places, minor bioturbation, fine to very coarse grained (at base), slightly kaolinitic.
		PRECAMBRIAN-weathered basement	24.5-24.7	Altered chlorite schist, blue-grey, clayey, slightly kaolinitic.
M-16-89 Seymourville	16-31-25-9E +240	ORDOVICIAN-Winnipeg	0.0-18.0	Sandstone, fine to coarse grained, red to yellow-grey, some limonite staining (lots of lost core).
		PRECAMBRIAN-weathered basement	18.0-19.0	Altered granitoid rock - consolidated - grey.
M-17-89 Seymourville	9-36-25-8E +240	Overburden	0.0-3.05	Recent sands and bouldery till.
		ORDOVICIAN-Winnipeg	3.05-15.4	Sandstone, coarse grained.
		PRECAMBRIAN-weathered basement	15.4-15.5	Altered granitoid rock.

GS-21 INDUSTRIAL MINERALS MAPPING, SWAN RIVER-MAFEKING AREA (63C and 62°)

by W.R. Gunter

Gunter, R. 1989: Industrial minerals mapping, Swan River-Mafeking area (63C and 62°); in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The goal of this project is to describe and evaluate all deposits of industrial minerals within NTS area 63C. In addition, an area in NTS 62O containing high calcium limestone was also investigated.

PREVIOUS INVESTIGATIONS

Numerous publications describe the various industrial mineral commodities in NTS 63C. These include industrial mineral reports on clay and shales (Bannatyne, 1970), high calcium limestone (Bannatyne, 1975) and silica sand (Watson, 1985) on a province-wide basis. The area is mentioned in publications on Manitoba's bentonite (Bannatyne, 1963), stratigraphic reports on the Cretaceous rocks (McNeil and Caldwell, 1981; Wickenden, 1945), the Swan River Formation (Venour, 1957), Devonian carbonates (Norris *et al.*, 1982), and surficial geology (Nielsen, 1988). Several guide books and field trip guides have been written on the Cretaceous rocks of southern Manitoba and the carbonate rocks of the Dawson Bay area. Numerous core holes have been completed by both industry and Manitoba Energy and Mines to document Devonian stratigraphy. Inland Cement's quarry, north of Mafeking is currently active. It has supplied limestone to the company's Regina cement plant since 1956. One former producer, Swan River Clay Products, Limited, produced approximately 219,000 light brown bricks from the Swan River Formation clays during the period 1953 to 1955.

Within NTS 63C and 62O there are four major targets for investigation. These are:

1. silica sand in the Swan River Formation;
2. kaolinitic clays in the Swan River Formation;
3. Cretaceous shales in the Ashville to Riding Mountain Formation; and
4. Devonian high-calcium limestone in the Souris River and Dawson Bay Formations.

SWAN RIVER FORMATION SILICA SAND

The silica sands of the Swan River Formation have been investigated by both Manitoba Energy and Mines (Watson, 1985), and private industry, as a source of glass grade silica and silicon metal.

A series of terraces, below the average prairie level, are present on both the Swan and Roaring rivers (Nielsen, 1988). The type section of the Swan River Formation outcrops at the base of the terraces, east of the town of Swan River. Exposures of Swan River Formation in these terraces are generally capped by only a layer of fluvial gravel and sand (Fig. GS-21-1).

The Swan River Formation sand, in outcrop, is unconsolidated so the river-cut cliffs are unstable and overgrown. A basal grey-brown kaolinitic clay, normally underlies the sand-rich units in outcrop. The top of the Swan River Formation is exposed at one location, with glauconitic Ashville shales unconformably overlying the typical sand section.

In all outcrops of the sand units, the contacts between sand and clay are transitional over 0.5 m. The clay-rich cross beds, within the sand units immediately above the contact with the clay beds, are thicker than those higher in the outcrop. This lowers the SiO_2 content of these transition beds.

The sand units of the Swan River Formation are consolidated, in one area and this makes sampling difficult. In two outcrops along the Roaring River, (north of the bridge on Highway No. 10) a 1 m thick sand unit has been cemented into a thin bedded sandstone (Fig. GS-21-2). The sandstone weathers to an aggregate of 1-3 cm spheroidal concretions. The outcrop to the east contains similar concretions occurring in a matrix of unconsolidated sand. There is more than one consolidated layer of sand within the Swan River Formation. A very similar type of sandstone layer occurs on the Red Deer River, as described by McNeil and Caldwell (1981) (outcrop 32 and 33). At the Red Deer River location neither the upper nor lower contacts of the Swan River Formation were exposed to indicate where in the section the consolidated layers occurred.

Future assessments of the silica potential of the Swan River Formation will require drilling and bulk sampling to determine the amount of SiO_2 over mineable volumes.

SWAN RIVER FORMATION KAOLINITIC CLAYS

Interbedded with, and underlying the silica sand of the Swan River Formation Bannatyne (1970) describes siltstones and claystones as "interbeds of shale and silty shale" within the "Swan River Group" (subsequently, the Swan River Formation (McNeil, 1977)). He analysed three shale samples chemically and mineralogically, and subjected them to temperature gradient tests to determine their suitability for brick. In our investigation several other outcrops of Swan River Formation clays were encountered and samples taken for comparison. One critical parameter is the presence of clay-size quartz. Tests by CANMET on a few samples from the Swan River shale show that the presence of clay-size quartz makes the kaolinite unusable as a paper filler.

Two main types of shale were encountered beneath the Swan River sand. In outcrop 84-89-SR-2-3 (Fig. GS-21-1) a complete section of the sand-clay contact is exposed. At the base of the sand a medium- to dark-grey, highly plastic, claystone occurs. This claystone is intermixed with the basal portion of the sand and extends about 2 m below the contact. In outcrop 84-89-SR-5-2 (Fig. GS-21-1), the contact with the silica sand is also exposed. The underlying clay is dark grey to black, very fine grained, plastic, and contains glauconitic beds at the transition zone with the sand portion of the unit. Minor ironstone concretions also occur in this section.

The second shale type is a light grey siltstone with abundant ironstone concretions, minor pyrite concretions and carbonaceous debris. Two large outcrops, on either side of the Swan River (84-89-SR-1-2 and 2-3) (Fig. GS-21-1), occur in the area of Bannatyne's (1970) samples and the brick company pit. Both outcrops consist of uniform, light grey siltstone with dark grey clay and sand units occurring as a channel-fill. Samples of this unit have been taken along the length of the outcrop and will be analysed to determine any significant difference in mineralogy and chemistry over the length of the outcrop.

OTHER CRETACEOUS SHALES OF THE DUCK AND PORCUPINE MOUNTAINS

Within NTS 63C map area, four distinctive shale to calcareous shale units outcrop at the lower edges of the northern Duck Mountains and on the south and northwest corners of the Porcupine Mountains. The east flank of the Porcupine Mountains, from Birch River north to the Burrows is a major landslide area (Nielsen and Watson, 1985). The creeks in this area contain sections of apparently undisturbed shale underlain by glaciofluvial gravel and highly disturbed shale sections, with anticlinal folds cored in sand and silt. Outcrops in this area contain sections that are out of stratigraphic sequence.

Several occurrences of shale that may have commercial possibilities have been previously described. McNeil and Caldwell (1981) mention several phosphatic layers within the shales of the Ashville Formation, that contain fish fragments and also phosphatic nodules.

Bannatyne (1970) tested shale samples from the Ashville Formation, the Favel Formation, the Morden Member and the Boyne Member for their brick making properties. Stratigraphic equivalents of all of these shales were sampled in the NTS 63C to determine their chemical and mineralogical compositions.

Bentonite beds, generally less than 2 cm thick, were encountered in NTS 63C. These will be analysed for comparison with bentonites presently in production in southern Manitoba.

SWAN RIVER FORMATION

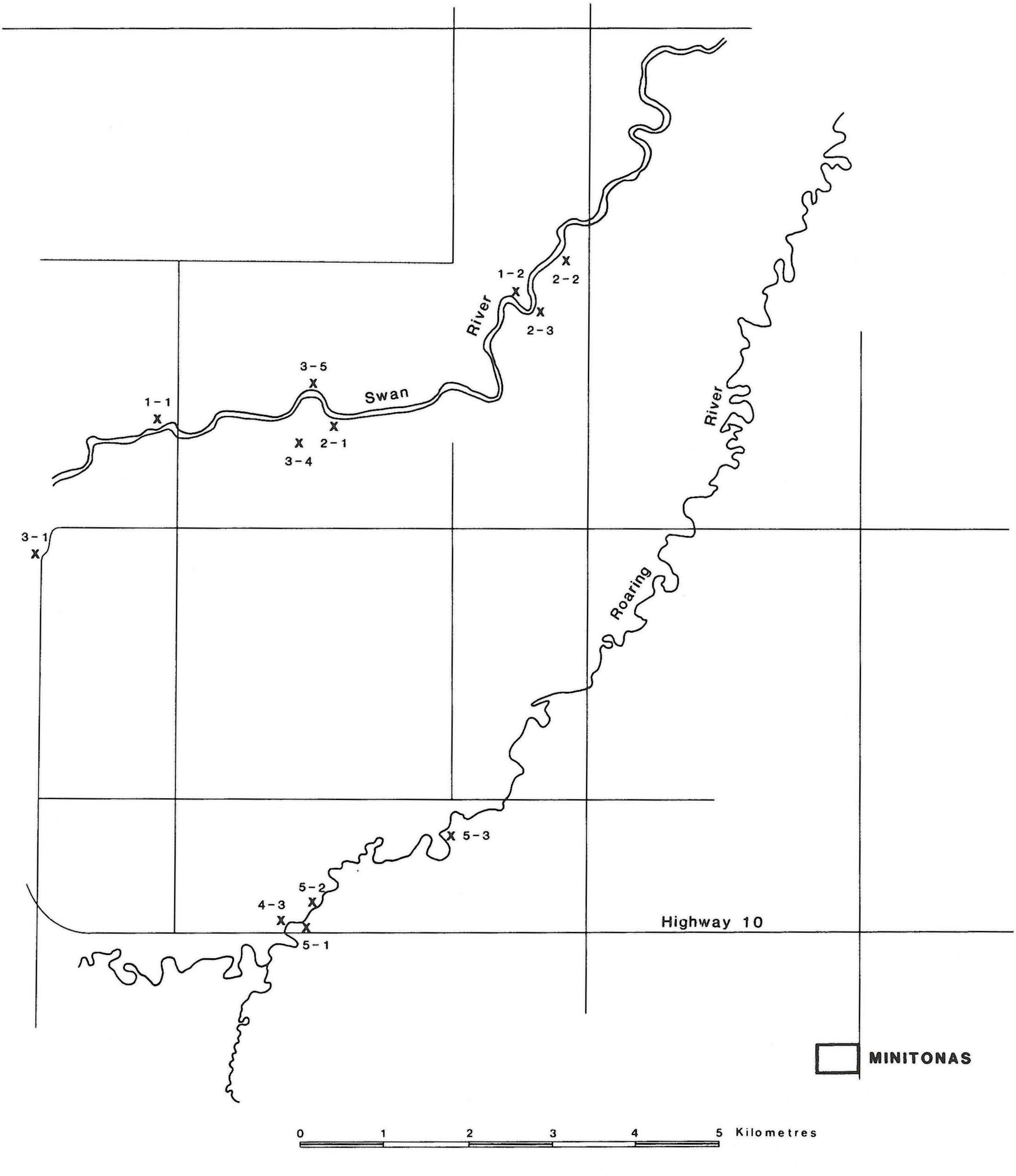

Figure GS-21-1: *Swan River Formation outcrops along the Swan River and Roaring River, location map.*

Figure GS-21-2: Swan River Formation sandstone on the Roaring River, north of Highway #10.

HIGH CALCIUM LIMESTONE

High calcium limestone occurs on the south and west shores of Dawson Bay (Fig. GS-21-3, in pocket). Available outcrops were mapped by Bannatyne (1979, 1981) and Norris *et al.* (1982), however subsequent highway construction, mineral exploration and logging have created new access routes to previously unmapped areas. The new outcrops were mapped to outline additional occurrences of high calcium limestone.

GS-21-3 differs in several respects from the maps of Norris *et al.* (1982) and Bannatyne (1979, 1981). Most significantly: Salt Point was found to be underlain mainly by Dawson Bay "B" beds, rather than by Winnipegosis dolomite; a new occurrence of Point Wilkins high-calcium limestone was discovered just west of the Village of Peliçan Rapids; and a more extensive cap of dolomitic limestone was documented overlying the Point Wilkins limestone.

No high calcium limestone was found in the Winnipegosis Formation. All outcrops are porous, reefy dolomite, that differ in texture from the Dawson Bay Formation and Point Wilkins Member limestone. The Dawson Bay "B" beds are highly fossiliferous, with abundant brachiopods and tend to be platy weathering. The "D" beds contain stromatoporoids and are locally a chemical grade limestone, with 99.59 per cent $CaCO_3$. The A and C beds are not exposed in outcrops.

The Point Wilkins Member is easily identifiable as a nodular weathering, sublithographic non-fossiliferous limestone. It occurs as an interreef deposit with flat to inward dipping beds, as opposed to the outward dipping beds of the Dawson Bay Formation zones.

The uppermost beds in the Devonian sequence are composed of medium- to coarse-grained dolomite with abundant pods and lenses of secondary calcite. This unit was considered a local dolomitization of the Point Wilkins member in previous mapping, and was not given member status within the Souris River Formation. The present mapping has revealed a much larger area underlain by dolomite than previously noted. In addition, erosional remnants of a dolomite cap occur overlying Point Wilkins Member beds along the road on the east side of Point Wilkins. Consideration should be given to establishing this unit as a separate member of the Souris River Formation.

HIGH CALCIUM LIMESTONE - PARADISE BEACH AREA

This area was mapped to examine the very high purity limestone in more detail, to determine its extent, the amount of overburden, and to determine if the stromatoporoidal lithology was a controlling factor in the calcium carbonate content of the rock.

Bannatyne (1975) briefly describes an area on the south shore of Lake Winnipegosis, southeast of the Town of Winnipegosis, where domal outcrops of stromatoporoidal limestone containing 99.47 percent and 99.79 per cent $CaCO_3$ have been sampled. A small quarry (Fig. GS-21-4) was active in the 1920's, in one area of the very high purity limestone, producing a product used as a whiting substitute.

One to two kilogram samples were collected from the high purity limestone for analyses. There were no visible impurities present. Most samples were collected in the area immediately surrounding the old quarry (Fig. GS-21-5) and in a new gravel pit (Fig. GS-21-6).

Several areas of sparsely treed pasture land with angular stromatoporoid bearing rubble and minor pavement outcrop occur between the gravel pit (Fig. GS-21-4, site 18-2) and the old quarry (Fig. GS-21-4, site 18-1). No recognizable outcrops exist to the west of the stromatoporoid bearing dome. The next ridge to the west (Fig. GS-21-4, site 19-2) contains stromatoporoids similar to those at Figure GS-21-4, site 18-2. To the north (Fig. GS-21-4, site 19-1) and east (Fig. GS-21-4, site 23-1) the outcrops are a fossilliferous biomicrite. In the case of (Fig. GS-21-4, site 23-1) the dome is topographically lower than the stromatoporoid bearing dome, but there is no exposure to establish their stratigraphic positions. Similarly, to the north there is no outcrop between the stromatoporoid bearing area and the biomicrite of Figure GS-21-4, site 19-1.

A newly excavated ditch (60 m long and 4 m wide) at site 23-4 (Fig. GS-21-4) exposes stromatoporoid bearing limestone in a low dome with little overburden. The stromatoporoids are integrated with corals and bryozoa. 0.75 km to the south, off the crest of the dome, site 23-3 (Fig. GS-21-4) exposes carbonate with almost no fossils.

Several samples were taken for analysis from each of the significant outcrops.

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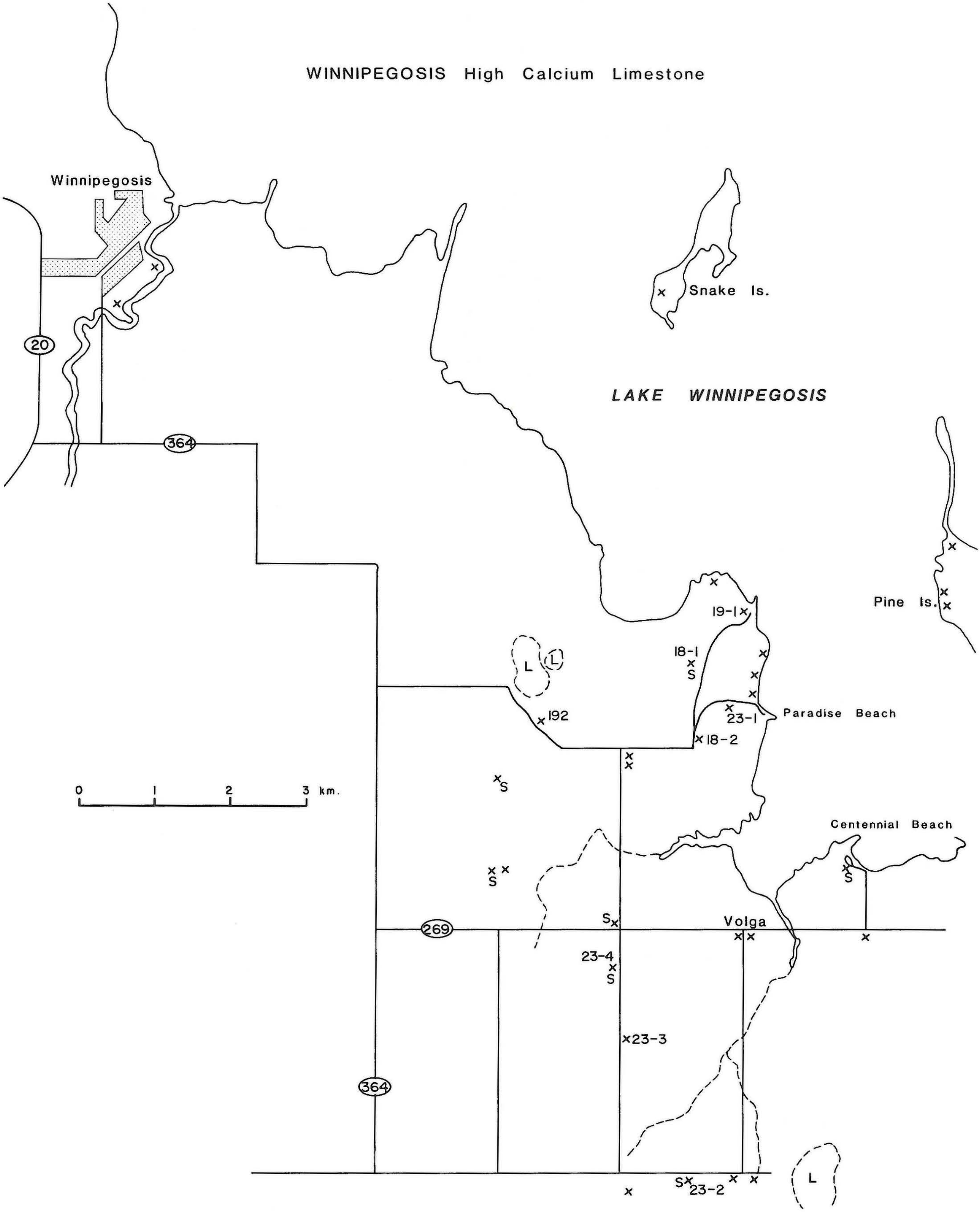

Figure GS-21-4: High calcium limestone, Winnipegosis area, location map.

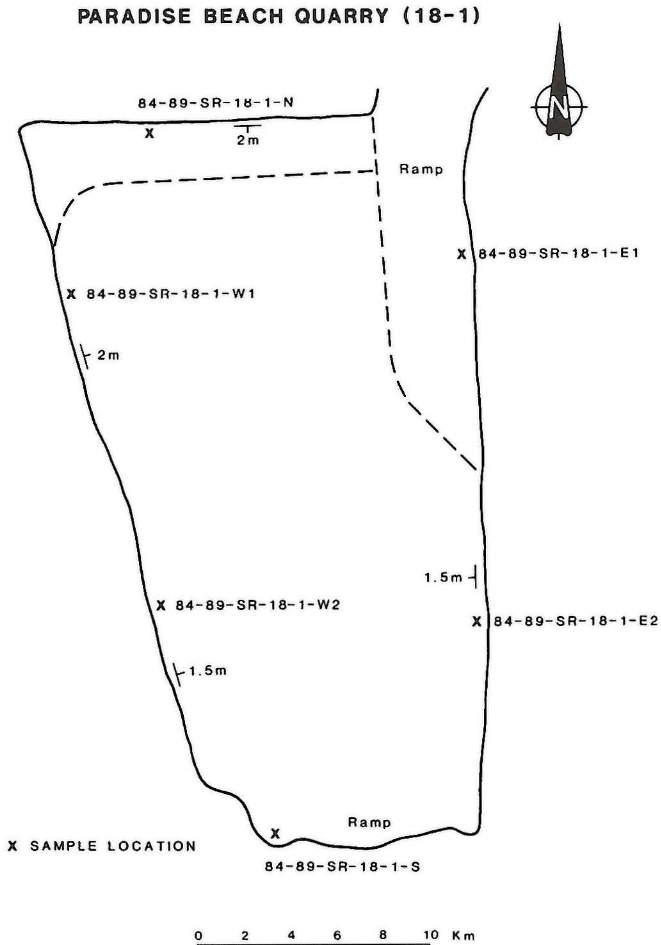

Figure GS-21-5: *Sketch map, Paradise Beach Quarry, location 18-1 (Fig. GS-21-4) showing sample locations.*

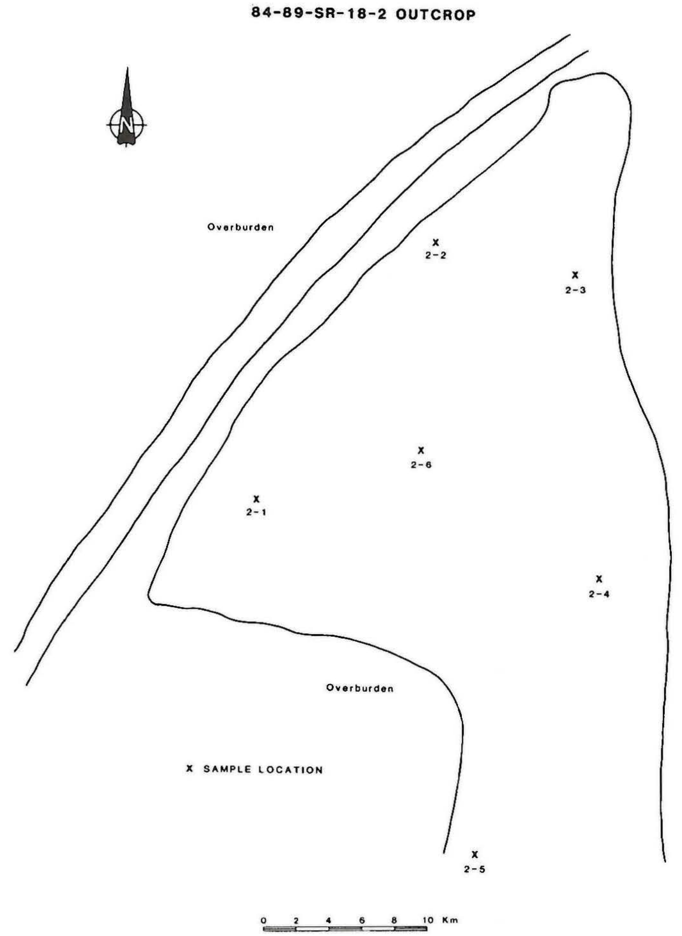

Figure GS-21-6: *Sketch map of location 18-2 (Fig. GS-21-4) showing sample locations.*

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GS-22 INDUSTRIAL MINERALS INVESTIGATIONS IN SOUTHERN MANITOBA

by P. Elias and B.E. Schmidtke

Elias, P. and Schmidtke, B.E. 1989: Industrial minerals investigations in southern Manitoba; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

A six week field program was conducted to assess the depths and quality of sphagnum bogs identified in the MDA remote sensing study of the Interlake (Dixon and Stewart, 1988). The bogs sampled, in the "St. Lakes" area, NTS 52P/11, 12, 13 and 14, are not of immediate interest for commercial development because large bogs of high quality sphagnum peat occur closer to Winnipeg. The purpose of this field program was to identify the mineral potential for Crown Land use plans and to ground truth the LANDSAT imagery maps produced in the remote sensing study. Thematic maps and 1:31 680 scale photo mosaics were used to identify twenty-five bogs for sampling. Locations of the bogs sampled are shown in Figure GS-22-1. Five of the twenty-five bogs, which are potential producers of horticultural sphagnum, are described here.

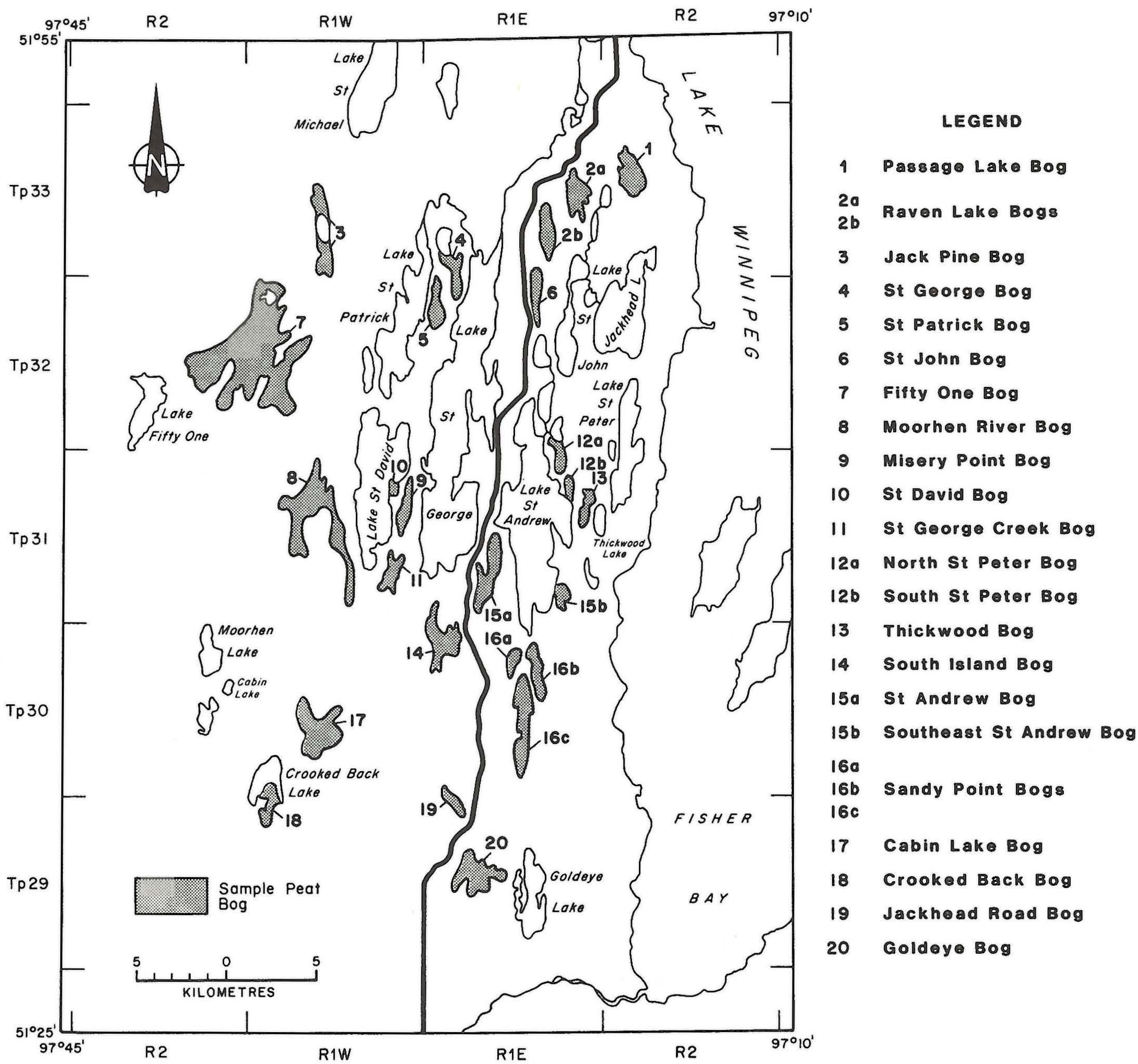


Figure GS-22-1: *Sampled bogs in Saint Lakes area.*

SPHAGNUM BOG DESCRIPTIONS

St. Patrick Bog

The St. Patrick bog is a good quality peat bog approximately 3 km long and 0.8 km wide. It lies between Lake St. George and Lake St. Patrick in Township 32, Range 1E (Fig. GS-22-2). The average depth of this bog is greater than 4.0 m over most of the sampled area. Several sample sites attained depths greater than 5.0 m. Surface sphagnum moss has an average thickness of 10-20 cm and supports dense black spruce and a few tamarac trees. Moderately dense Labrador tea covers the surface.

The peat in the deepest part of the bog is consistently little humified, light brown to brown and medium fibred throughout the cores obtained. Sphagnum contents are between 70% and 90% down to the 5.0 m level in some sample cores (Fig.GS-22-3). In the southern, shallower part of the bog (south of sample E76 Fig.GS-22- 3a), the peat is moderately to strongly humified. The St. Patrick bog has estimated reserves of 5.2 million cubic metres, equivalent to 520 000 tonnes of peat product (Table GS-22-1).

St. George Bog

The St. George bog is located between Lake St. Patrick and Lake St. George in Townships 32 and 33, Range 1E (Fig. GS-22-2). The bog is approximately 3.8 km long and 0.4 km wide. The north half of the bog is deeper than the south half. The maximum depth sampled was 3.68 m (Fig. GS-22-4a). The surface sphagnum moss ranges in thickness from 10-30 cm and has a dense to very dense coverage of black spruce trees and Labrador tea. Grasses and shrubs become abundant along the outer 100 m of the bog.

A medium- to high- quality peat is found in the bog sampled in E63-E69 (Figs. GS-22-4a and 22-4b). It is brown, little humified, medium fibre peat to an average depth of approximately 0.95 m. Below the 1.0 m level, the peat becomes moderately to strongly humified and eventually black in colour. The southern portion of the bog is a low quality peat that is dark brown and shows considerable humification. Only a portion of the upper part of the bog is considered in estimating the reserves of the bog shown in Table GS-22-1.

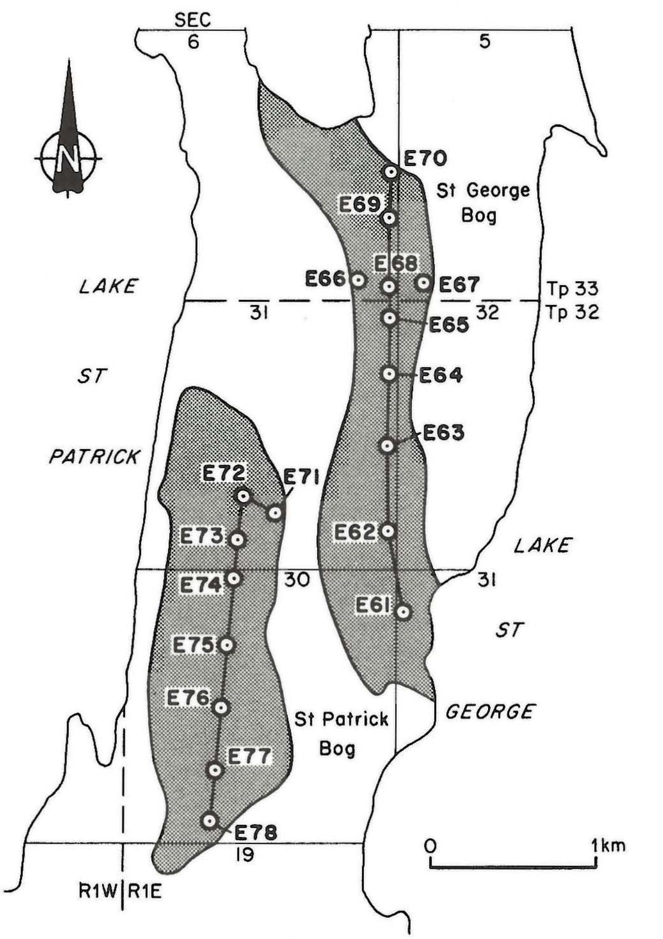


Figure GS-22-2: St. George Bog and St. Patrick Bog location map.

St. George Creek Bog

This bog is 2 km and 0.5 km wide. It is located between Lake St. David and Lake St. George (Fig. GS-22-5) in Township 31, Range 1W. The surface of this bog is covered by moderately dense black spruce with minor tamarac trees and few grasses and shrubs. The upper 20-30 cm of the bog consists of new sphagnum moss that has a fairly dense cover of Labrador tea. A maximum sampled depth of 4.5 m was obtained (Fig. GS-22-6). The peat at this location consists of 75-80% sphagnum moss to a depth of 3.5 m and is medium to high quality and moderately humified. In other sample locations, the peat with more than 75% sphagnum is less than 1.0 m thick.

Southeast St. Andrew Bog

This small bog partially borders the southeast shore of Lake St. Andrew and covers an area of 0.60 km^2 in Township 31, Range 1E (Figure GS-22-7). Depth of the peat exceeds 2.7 m in the centre of the bog. The bog, which was burned by forest fires in 1989, is covered with the remains of a dense black spruce forest. Surface sphagnum is burned to a depth of approximately 15 cm.

The peat at the sampled site is of medium- to high- quality. It has a low to moderate degree of humification, dark brown color and medium fibre to a depth of 2.0 m. Below this, the peat is black, fine, and strongly humified. In the upper 2.0 m the sphagnum content is estimated at 90% (Figure GS-22-8).

Thickwood Bog

The Thickwood Bog lies between Lake St. Andrew and Thickwood Lake (Fig. GS-22-9) and has an estimated surface area of 1.52 km^2. It is located in Township 31, Range 1E, NTS sheet 62P/11. Two cores were taken at the southern end of the bog. The first, sample E124, was taken in an area with a thin cover of black spruce and a dense cover of Labrador tea. The depth at this location is 1.93 m and the peat grades from relatively humified, brown peat containing 80% sphagnum in the upper 0.5 m, to strongly humified, dark brown to black peat containing 40% sphagnum in the lower 0.43 m (Fig. GS-22- 10). The second core was taken in an area of very dense black spruce and Labrador tea cover. The depth of peat is 3.0 m, of which the upper 1.5 m is good quality sphagnum.

Thematic Maps

The high quality peat bogs are identified on the LANDSAT map as "open bog with low shrub" often surrounded by areas of "closed conifer treed" bog and "ericoid/sphagnum" bog. The areas on the maps classified as "sphagnum/ericoid" are generally in wet, difficult to access areas and contain low- to medium-quality peat moss.

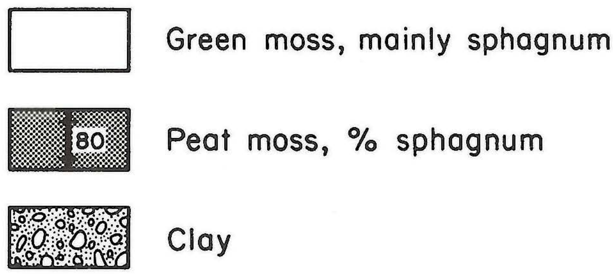
CONCLUSION

The Saint Lakes area contains some high potential sphagnum peat bogs. The bogs having the highest potential are the St. Patrick Bog and the St. George Bog. In general, these bogs, as well as other high potential bogs, all appear to occur in areas of dense black spruce coverage with few grasses or shrubs. On the LANDSAT-5TM maps, the high potential bogs have large areas of "open bog with low shrub". This is often surrounded by areas of "closed conifer/treed" bog and "ericoid/sphagnum" bog. The areas on the LANDSAT maps classified as "sphagnum/ericoid" bogs are, generally, in wetter, difficult to access, areas and contain a medium to low potential peat moss.

The other bogs that show a high potential are the St. George Creek, Southweast St. Andrew, and Thickwood bogs. The medium potential bogs are the Raven Lakes, St. David, Misery Point, St. John, St. Andrew and Fifty-One bogs. All other bogs sampled in this study have low potential for peat.

LEGEND

(APPLIES TO ALL FIGURES)



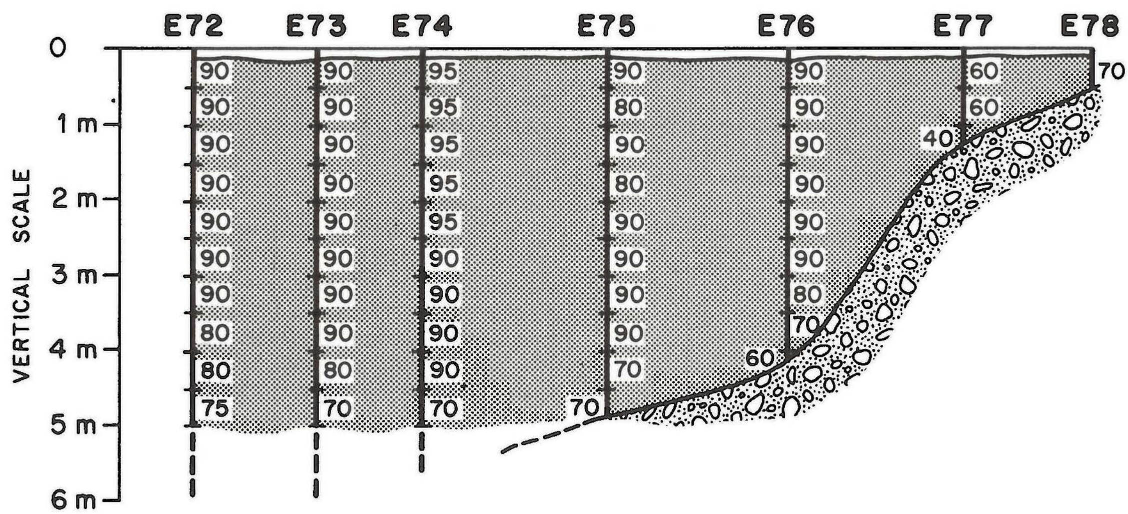


Figure GS-22-3a: *North-South cross-section of St. Patrick Bog.*

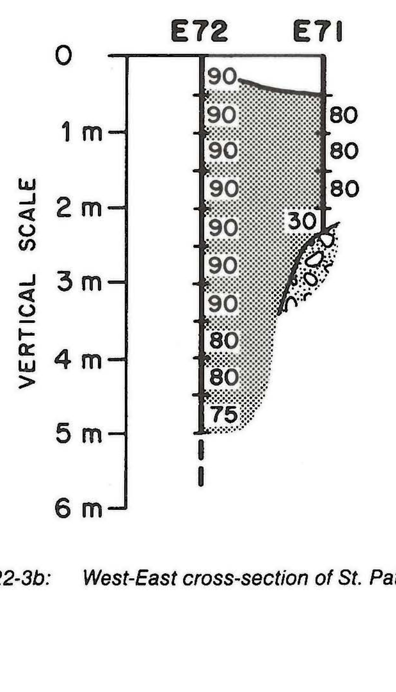


Figure GS-22-3b: *West-East cross-section of St. Patrick Bog.*

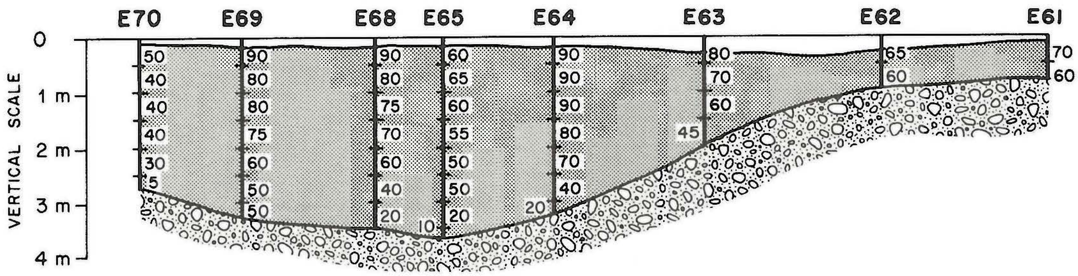
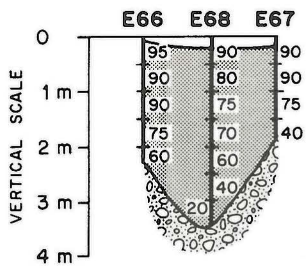


Figure GS-22-4a: *St. George Bog North-South cross-section.*



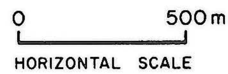


Figure GS-22-4b: *St. George Bog West-East cross-section.*

TABLE GS-22-1
SUMMARY OF ESTIMATED POTENTIAL RESERVES OF THE HIGH POTENTIAL SPHAGNUM PEAT BOGS IN THE SAINT LAKES AREA

Bog	Area of High Potential (Km^2)	Average Depth (m)	Volume (million m^3)	Tonnes of Product (x 1000)	% Sphagnum	Remarks
St. Patrick	1.3	4.0	5.20	520	75-90	
St. George	1.02	0.95	0.969	96.9	75-90	One hole has 60-65% sphagnum
St. George Creek	0.87	2.0	1.74	174	70-80	
S.E. St. Andrew	0.6	1.0	0.6	60	80	Only one hole
Thickwood	1.52	1.5	2.28	228	75-90	Only one hole

SEYMOURVILLE SILICA SAND

Three outcrops of high purity silica sand of the Ordovician Winnipeg River Formation located near Seymourville were sampled previously by Watson (1985). A core drilling program was carried out in the 1989 field season to establish the thickness and quality of silica sand and to determine the depth of overburden.

Silica sand near Seymourville is located at the base of the Ordovician Winnipeg River Formation which is quarried for sand on Black Island, approximately 5 km northwest of Seymourville, by Selkirk Silica. The Black Island deposit is one of the purest silica sources in North America.

Seven drill holes were completed. The locations and logs of the holes are shown on Figure GS-22-11 and Table GS-22-2 respectively. Four of the holes, M-11, M-15, M-16 and M17 intersected approximately 4 m of overlying till and 18 m of silica sand. Palaeozoic rocks are not present in M-12 and M- 13 presumably because the holes were drilled beyond the eastern margin of the Ordovician directly into weathered Precambrian greenstone. Hole M-14 ended in boulder till. The sequence in M-11, M-16 and M-17 is boulder till, fine- to medium-grained iron stained silica sand, kaolinitic silica sand, kaolin, green clay, weathered chlorite schist. Hole M- 15 is similar except that 30 cm of coarse grained silica sand occurs between the kaolinitic silica sand and the green clay. A 20 cm thick layer of black sandstone containing pyrite oolites occurs at 9.6 m in hole M-11. Three metres of gray to black argillaceous sandstone occurs between 6.8 and 9.8 metres in hole M-15, which contains pyrite oolites at approximately 9 m.

The core samples will be sieved and chemically analyzed to determine grain size and purity in the fall of 1989.

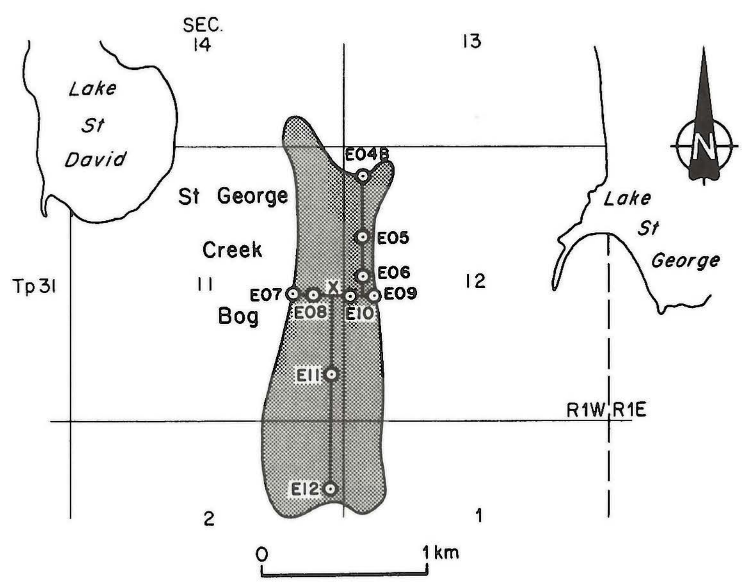


Figure GS-22-5: *St. George Creek Bog location map.*

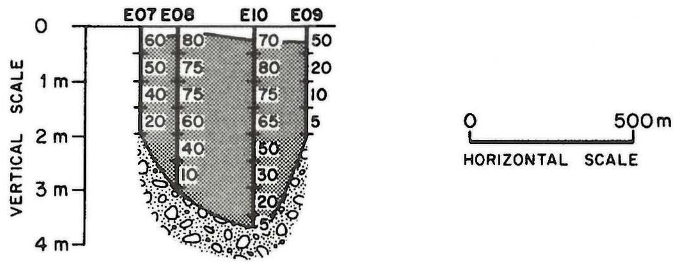


Figure GS-22-6a: *West-East cross-section of St. George Creek Bog.*

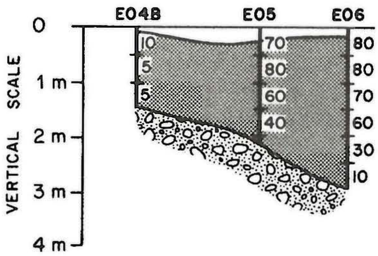


Figure GS-22-6b: *North-South cross-section of St. George Creek Bog.*

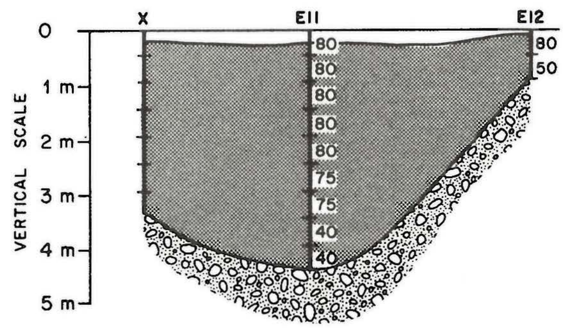


Figure GS-22-6c: *North-South cross-section of St. George Creek Bog.*

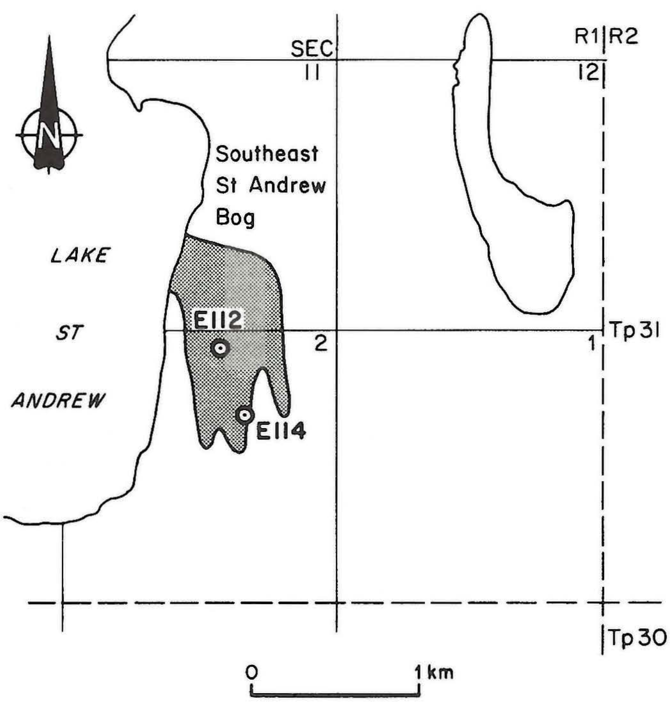


Figure GS-22-7: *Southeast St. Andrew Bog location map.*

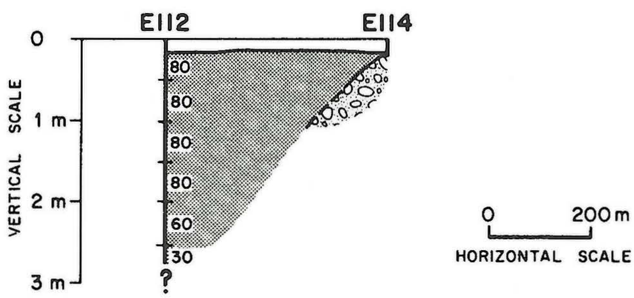


Figure GS-22-8: *North-South cross-section of southeast St. Andrew Bog.*

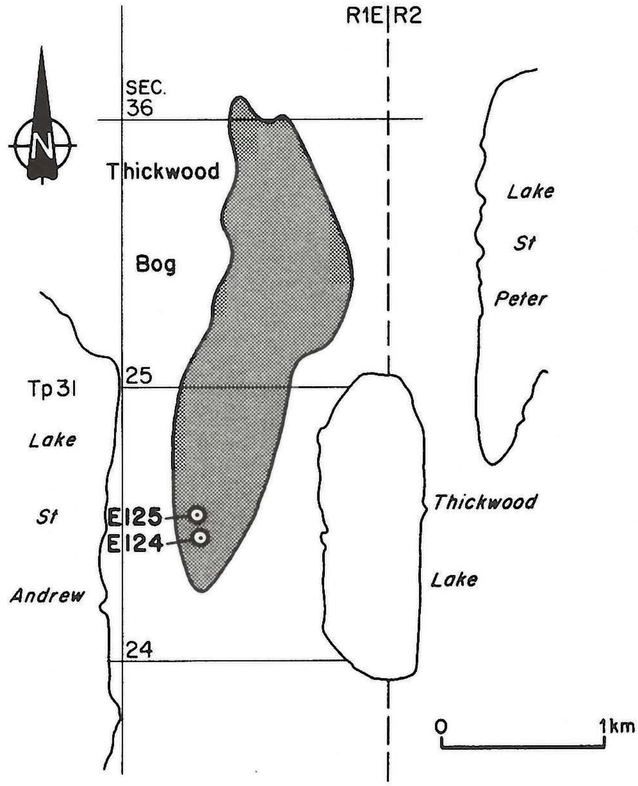


Figure GS-22-9: *Thickwood Bog location map.*

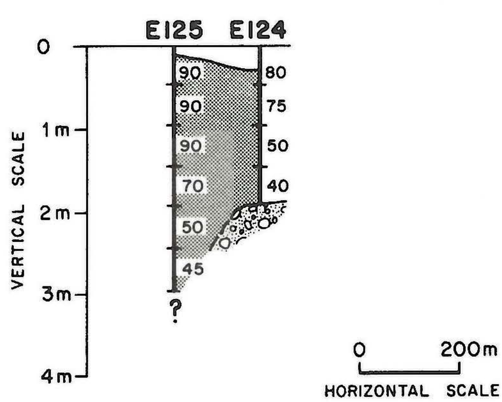


Figure GS-22-10: *Thickwood Bog cross-section.*

TABLE GS-22-2

DRILL LOGS OF SEYMOURVILLE HOLES

M-11	
0 - 2.45 m	boulder till
2.45 - 3.75 m	glacial sand
3.75 - 6.79 m	yellow stained, fine grained silica sand
6.79 - 8.31 m	silica sandstone, some red iron staining
8.31 - 9.6 m	silica sandstone
9.6 - 9.83 m	black sandstone containing pyrite oolites
9.83 - 11.35 m	no recovery
11.35 - 14.91 m	3 cm of silica sand recovered
14.91 - 22.56 m	kaolinitic silica sand
22.56 - 22.75 m	green clay
22.75 - 23.5 m	weathered chlorite schist
EOH	
M-17	
0 - 3 m	boulder till
3 - 20 m	silica sand
20 at	chlorite schist
EOH	
M-13	
0 - 8.89 m	grey plastic clay
8.89 - 11.93 m	no recovery
11.93 - 13.45 m	boulder till
13.45 - 14.97	arenaceous clay
14.97 - 15.52	weathered chlorite schist
EOH	
M-12	
0 - 9.15 m	grey-brown plastic clay
9.15 - 10.67 m	grey kaolinitic clay and sand
10.67 - 12.19 m	kaolinite to grey clay to weathered Precambrian
EOH	
M-14	
0 - 18 m	boulder till
EOH	
M-15	
0 - 3.75 m	boulder till
3.75 - 6.8 m	iron stained silica sand
6.8 - 8.32 m	grey argillaceous sandstone containing pyrite oolites
8.32 - 9.84 m	grey to black sandstone
9.84 - 15.92 m	white, fine grained silica sand
15.92 - 22.00	kaolinitic silica sand
22.00 - 23.52	lost recovery
23.52 - 24.40 m	progressively coarser grained silica sand
24.40 - 24.70 m	green clay, weathered chloritic schist
EOH	
M-16	
0 - 18 m	silica sand
at 18 m	weathered Precambrian
EOH	

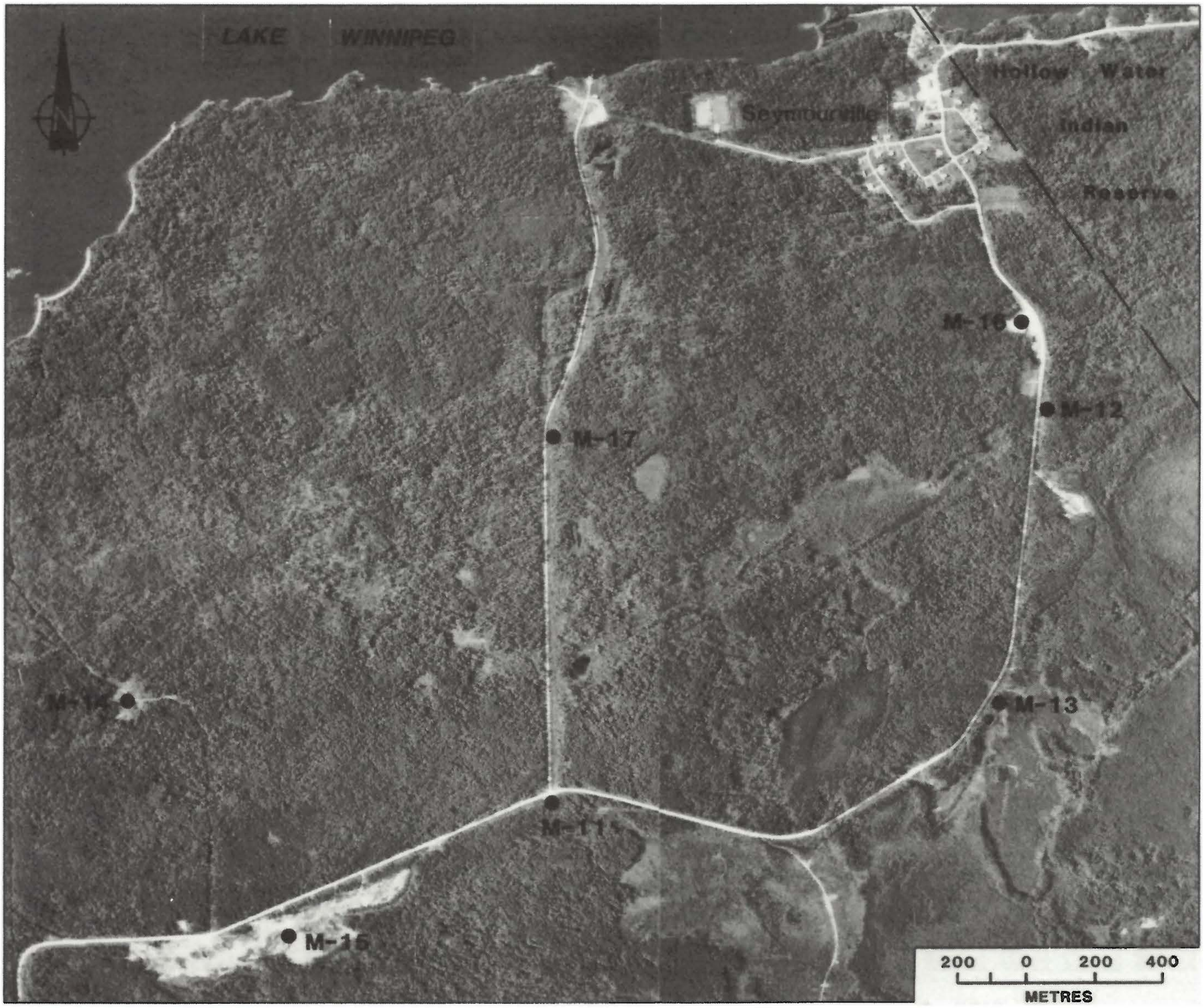


Figure GS-22-11: Core hole locations near Seymourville.

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GSC-1 METAMORPHISM OF THE HOST ROCKS TO THE NORTH COOK LAKE MASSIVE SULPHIDE TYPE COPPER DEPOSIT, SNOW LAKE AREA (NTS 63K/16)

by E. Froese, D.R. Lemkow and M.A.F. Fedikow[1]

Froese, E., Lemkow, D.R. and Fedikow, M.A.F. 1989: Metamorphism of the host rocks to the North Cook Lake massive sulphide type copper deposit, Snow Lake area (NTS 63K/16); in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The North Cook Lake massive sulphide type copper deposit occurs in the Snow Lake portion of the Proterozoic Flin Flon-Snow Lake greenstone belt in west-central Manitoba (Fig. GSC-1-1). The host rocks are subaqueously deposited mafic flows, ash, tuff and agglomerate and subaqueously to subaerially deposited felsic pyroclastic and flow rocks. These rocks have been assigned to the Amisk Group. The general geology in the area of the deposit has recently been mapped by Bailes (1988). A simplified version of this map is presented in Figure GSC-1-2.

The host rocks have been hydrothermally altered to a coarse grained alumino-silicate mineral assemblage characterized by almandine, cordierite, anthophyllite, staurolite, kyanite and sillimanite. Within this concordant alteration zone, sulphide mineralization occurs as stacked, near solid to solid lenses of pyrrhotite, pyrite, chalcopyrite and rare sphalerite. Typical assay values over 1 m core intervals are 1.3 % Cu, 0.01% Zn, trace Au and 10 g/t Ag. Metal zoning in the massive sulphide lenses is inconsistent, varying between Cu-rich cores and Zn-rich margins to Cu-rich tops and Zn-rich bases. Weak metal zoning consisting of a Cu-rich base and a Zn-rich top are observed at the Bomber Cu-Zn deposit in the southern portion of Cook Lake (Jackson, 1983; Fig. GSC-1- 2). Both the North Cook Lake and Bomber deposits have characteristics of distal volcanogenic massive type sulphide deposits. The apparent absence of an alteration pipe that acted as a feeder or plumbing system for metal transport to the site of sulphide deposition may be related to the fact that much of the alteration zone and contained mineralization lies beneath Cook Lake, thereby restricting documentation to examination of drill core. The study of this zone is further complicated by four deformational episodes and metamorphism that attained amphibolite facies conditions (Jackson, 1983).

[1]Manitoba Energy and Mines, Winnipeg, Manitoba

Publications and geological maps at various scales describing the geology of the area were produced by Alcock (1920), Harrison (1949), and Froese and Moore (1980). Detailed mapping, geophysical and geochemical work has been undertaken by Hudson Bay Mining & Smelting Co. Ltd. (1954-63) and by Falconbridge Ltd., the current owners. A 1:20 000 scale map, including the Cook Lake area, has recently been released by Bailes (1988). Mineralization and alteration at Cook Lake formed the basis for an M.Sc. study by Jackson (1983) from which most of this introduction has been derived.

OBJECTIVES OF THE STUDY

The Cook Lake alteration zone has received previous geochemical and mineralogical study by Jackson (1983), examining the history of volcanic activity and the genesis of the altered volcanic host rocks. Silicate whole rock and electron microprobe analyses were utilized to find possible geochemical indicators of proximity to copper bearing sulphide mineralization. Despite examining the variability of the chemical composition of garnet, biotite and chlorite and utilizing geochemical indicators, such as Na_2O + CaO from whole rock geochemical data, Jackson (1983) was unable to identify geochemical indicators of proximity to copper bearing mineralization.

In light of these observations the current study was undertaken to examine (i) the reactions producing the metamorphic mineral assemblages observed in the North Cook Lake alteration zone and (ii) the variation in concentration of trace elements in the host rocks to the deposit. (Fedikow and Lemkow, 1989) Both studies will attempt to determine whether a geochemical exploration technique can be derived that will be useful in delineating copper-bearing massive sulphide type mineralization in the Cook Lake area. Observations in this report are based upon samples collected from DDH C85 and C87, collared in the North Cook Lake area.

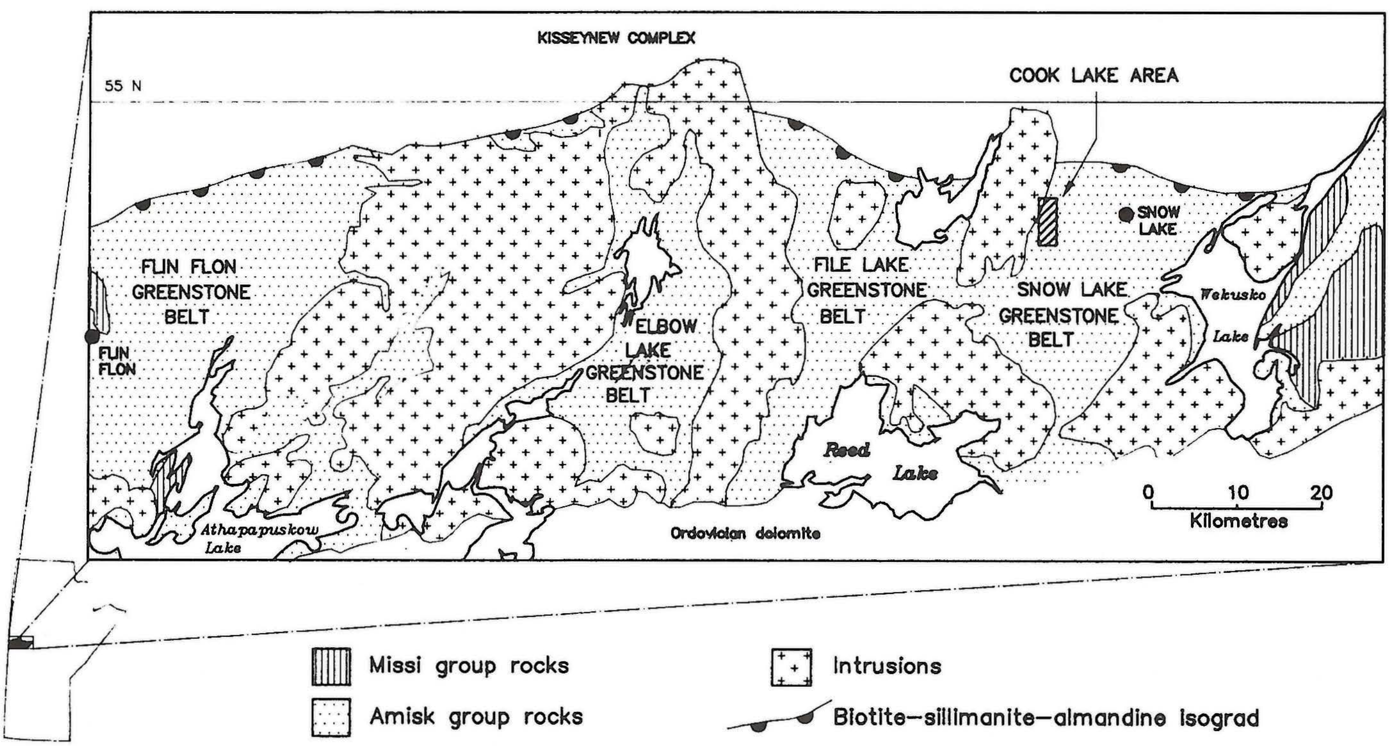

Figure GSC-1-1: Location map and regional geology of the Cook Lake area.

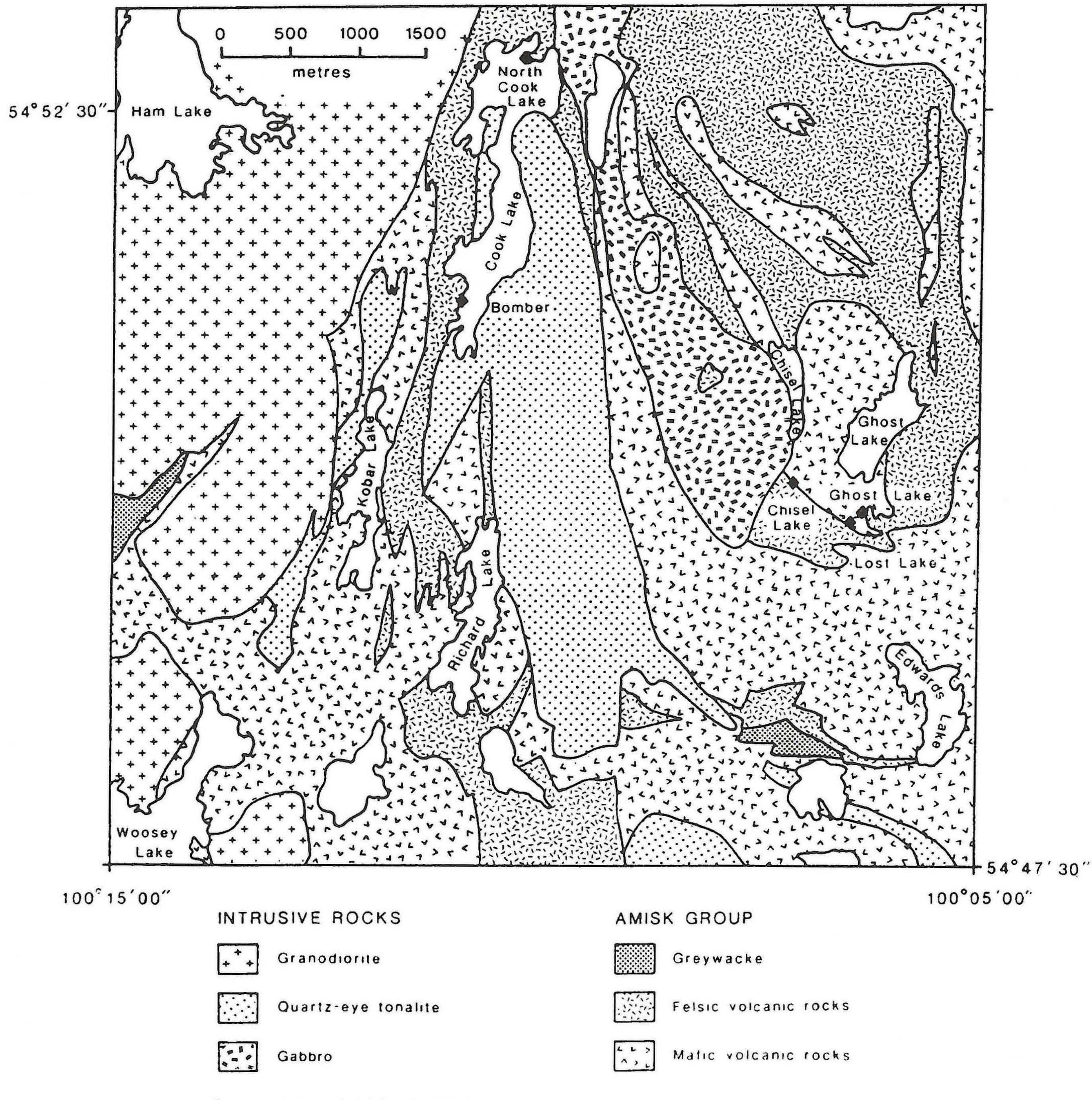

Figure GSC-1-2: Location of the North Cook Lake deposit (geology simplified from Bailes, 1988).

METAMORPHIC MINERAL ASSEMBLAGES

In the Snow Lake area, three isograds have been mapped (Froese and Moore, 1980). One of these, based on the reaction chlorite + staurolite + muscovite + quartz = biotite + Al silicate + H_2O is located in the vicinity of Chisel Lake marking the lower limit of the biotite-staurolite-sillimanite zone. Within this zone, a series of reactions is required to stabilize the mineral assemblages observed in the North Cook Lake deposit:

chlorite + almandine + quartz = anthophyllite + staurolite + H_2O
chlorite + muscovite + quartz = biotite + Al silicate + cordierite + H_2O
chlorite + Al silicate + quartz = staurolite + cordierite + H_2O
chlorite + staurolite + quartz = anthophyllite + cordierite

The occurrence of the assemblages kyanite-sillimanite and sillimanite-staurolite-cordierite-anthophyllite is taken as an indication that metamorphic conditions were close to the intersection of the kyanite-sillimanite transition with the reaction

staurolite + cordierite + quartz = anthophyllite + Al silicate + H_2O

A postulated sequence of reactions on the present erosion surface between Chisel Lake and Cook Lake is shown in Figure GSC-1-3.

Examples of mineral assemblages from the Cook Lake alteration zone are listed in Table GSC-1-1 and mineral analyses are given in Table GSC-1-2. Three analyzed plagioclases have the following compositions C85-136, An_{55}, (C85-267) An_{42}, C85-281 An_{41}. Anhydrite was noted in one sample (C85-473).

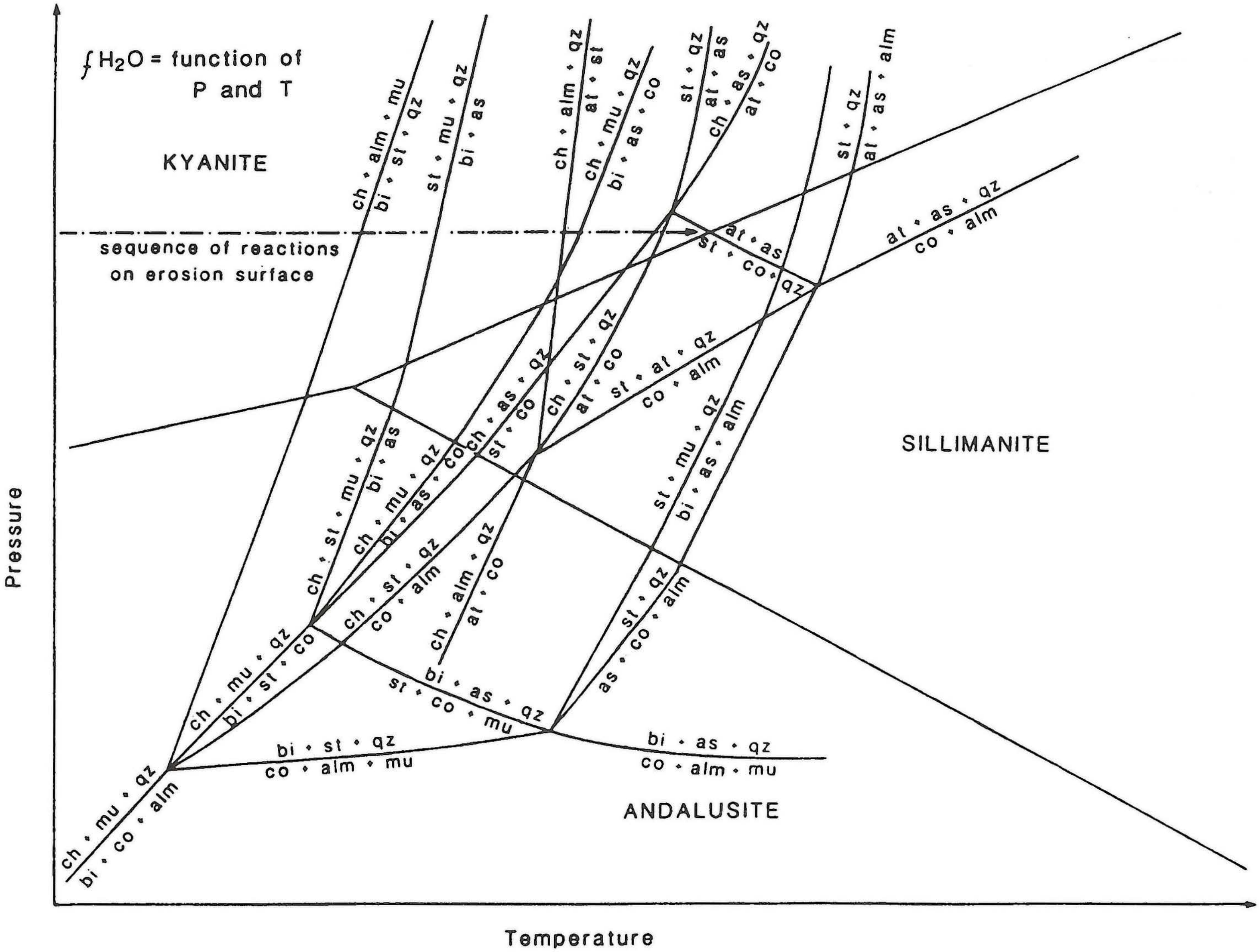

Figure GSC-1-3: Reaction grid for pelitic rocks; modified from Hess (1969) and D.M. Carmichael (pers. comm., 1978): see Bailes and McRitchie (1978).

At constant pressure, temperature and fH_2O, and in the presence of quartz and plagioclase of constant composition, non-potassic minerals can be represented approximately in the system

$A = Al_2O_3 - (Na_2O + CaO)$
$F = FeO$
$M = MgO$

as shown in Figure GSC-1-4. Chlorite, considered to be a retrograde mineral, has been disregarded. Minerals coexisting with quartz and muscovite can be represented approximately in the system

$A = Al_2O_3 - 3\,K_2O$
$F = FeO$
$M = MgO$

as shown in Figure GSC-1-5. In order to consider magnetite (mt) as a phase, oxygen is introduced as a component and, at constant fO_2, magnetite plots at the FeO corner. Introducing S as an additional component will stabilize either pyrrhotite (Po) or pyrite (Py). In many cases, the pyrite-pyrrhotite boundary is not as sharply defined as expected from theoretical considerations. The presence of pyrite in iron rich rocks might indicate a retrograde reaction at low temperatures.

STABILITY OF GAHNITE

Gahnite is a common mineral in metamorphosed sulphide deposits, where it apparently forms by desulphidation of sphalerite (Spry and Scott, 1986). The introduction of Zn as a component will, in general, lead to the appearance of one additional phase, either gahnite or sphalerite (Sph). The nature of the gahnite-sphalerite boundary is examined by showing phase relations on a diagram of log fO_2 vs. log fS_2 (Fig. GSC-1-6). Equilibria involving gahnite, sphalerite and aluminous minerals can be written to involve the fugacities of O_2 and S_2 as variables (Wall and England, 1979; Spry and Scott, 1986; Zaleski, 1989). In the system

SiO_2-Al_2O_3-FeO-MgO-K_2O-H_2O-Zn-O_2-S_2

six phases together with quartz and muscovite, constitute an invariant assemblage at constant P, T, and fugacity of H_2O.

Thus the four three-phase silicate assemblages in Figure GSC-1-5, in each case with gahnite, sphalerite and pyrrhotite, define four invariant points shown in Fig. GSC-1-6. Reactions extending from the invariant points can be balanced using the composition of minerals. The balanced reactions provide slopes given by the ratio S_2/O_2 in the reaction equation. The slopes were used as a guide to establish the correct sequence around an invariant point. In order to avoid crowding of lines the drawn slopes are diagrammatic. Equilibria encountered along a particular fugacity of O_2 are indicated in Figure GSC-1-5 by showing the gahnite-sphalerite boundary in the magnetite-almandine, almandine-biotite, and biotite - Al silicate fields.

ACKNOWLEDGEMENTS

The samples, for this study were obtained from Falconbridge Limited. Discussions with E. Zaleski were very helpful in constructing the reaction grid.

TABLE GSC-1-1
Mineral assemblages identified in thin sections from DDH C85 and C87, North Cook Lake alteration zone

DDH Sample	qz	pl	mu	bi	ky	si	alm	st	co	at	cu	hb	ep	spn	gah	ch	cal
C85-136	x	o		o			o				o						
C85-159	x	x		x								x	x	x	x		
C85-163	x	x		o								o	o		x		
C85-176	x	x		o			o					o				x	x
C85-239	x	x	x	x			x									x	
C85-267	x	o	x	o		x	o	o							o	x	
C85-274	x	x		x	x	x		x								x	
C85-281	x	o		o	x	x	o	o								x	
C85-292	x	x	x	x				x								x	
C85-323	x	x		x		x	x										
C85-338	x	x	x	x		x										x	
C85-419	x	x		x	x	x			x							x	
C85-435	x	x		x					x	x							
C87-473	x	x		x													
C85-490	x	x		x		x		x	x								
C85-534	x			o		x		o	o	o						x	
C85-726	x			x				x	x							x	
C87-99-2	x	x		o				o		o						x	
C87-108	x	x	x			x	o	o								x	x

Key to mineral abbreviations:

qz - quartz
pl - plagioclase
mu - muscovite
bi - biotite
ky - kyanite
si - sillimanite
alm - almandine
st - staurolite
co - cordierite
at - anthophyllite
cu - cummingtonite
hb - hornblende
ep - epidote
spn - sphene
gah - gahnite
ch - chlorite
cal - calcite
o - analyzed minerals

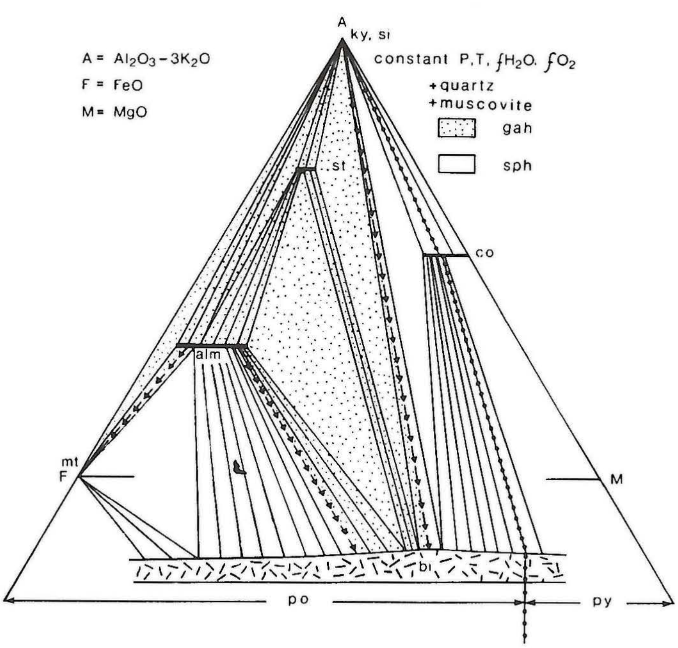

Figure GSC-1-4: AFM diagram for non-potassic mineral assemblages.

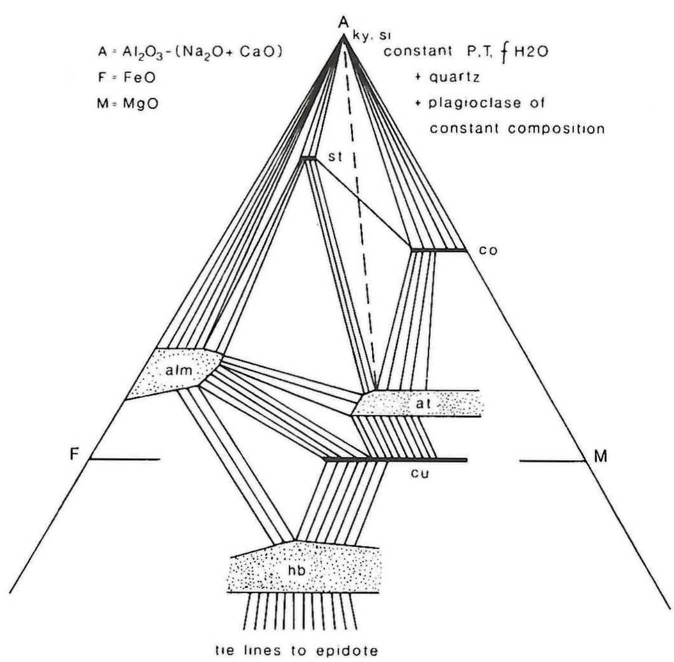

Figure GSC-1-5: AFM diagram for mineral assemblages with quartz and muscovite.

TABLE GSC-1-2
Selected mineral analyses, North Cook Lake area, DDH-C85 and C87

		C85-136			**C85-163**			**C85-176**			**C85-267**		
	bi	alm	cu	bi	hb	ep	bi	alm	hb	bi	alm	gah	st
SiO_2	36.76	38.25	53.49	36.50	42.43	38.12	35.39	37.82	41.34	37.19	37.66	-.-	27.51
TiO_2	1.66	-.-	0.04	2.00	0.53	0.13	2.24	0.04	0.52	1.46	-.-	-.-	0.33
Al_2O_3	17.72	21.51	1.52	17.61	12.20	26.39	17.45	21.03	15.06	19.95	20.66	58.38	52.66
FeO	15.64	31.63	24.31	22.62	18.44	7.09	19.14	25.85	18.95	14.96	19.73	8.66	8.14
MnO	-.-	1.03	0.20	0.29	0.42	0.15	0.22	5.64	0.42	0.29	15.93	0.36	0.82
MgO	12.98	3.95	16.29	10.03	7.76	-.-	9.35	1.89	6.77	14.13	3.22	2.62	2.11
CaO	-.-	3.71	0.59	-.-	11.66	23.40	-.-	7.22	11.21	-.-	2.25	-.-	-.-
Na_2O	0.19	-.-	0.09	0.10	1.06	0.06	0.05	-.-	1.09	0.17	-.-	-.-	-.-
K_2O	8.53	-.-	-.-	9.26	1.31	-.-	9.65	-.-	0.84	9.20	-.-	-.-	-.-
ZnO	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	29.76	5.60
F	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	-.-	0.50	-.-	-.-	-.-
TOTAL OXIDES	93.48	100.08	96.53	98.41	95.81	95.34	93.67	99.49	96.20	97.35	99.45	99.77	97.17

		C85-281			**C87-99**			**C87-108**			**C85-534**		
	bi	alm	st	bi	st	at	bi	alm	st	bi	at	st	co
SiO_2	36.74	37.96	27.61	37.90	27.27	44.25	36.76	37.79	27.51	38.73	50.58	27.68	49.05
TiO_2	1.41	-.-	0.37	1.35	0.64	0.16	1.18	-.-	0.33	1.20	0.04	0.43	-.-
Al_2O_3	19.15	21.20	53.49	18.78	52.62	15.20	19.54	20.75	52.57	18.17	6.43	53.65	33.47
FeO	13.41	28.60	13.12	14.72	11.42	19.59	16.54	26.18	11.94	12.10	21.16	12.97	4.93
MnO	0.10	5.17	0.37	0.03	0.11	0.34	0.17	7.95	0.64	-.-	0.19	0.06	0.04
MgO	14.00	4.69	2.58	15.54	2.32	14.57	14.64	4.81	2.36	15.93	17.68	2.83	10.36
CaO	-.-	2.15	-.-	-.-	-.-	0.32	-.-	1.98	-.-	-.-	0.21	-.-	-.-
Na_2O	0.40	-.-	-.-	0.33	-.-	1.56	0.17	-.-	-.-	0.37	0.68	-.-	0.18
K_2O	8.98	-.-	-.-	8.29	-.-	0.06	8.74	-.-	-.-	8.81	-.-	-.-	-.-
ZnO	-.-	-.-	0.09	-.-	1.48	-.-	-.-	-.-	1.31	-.-	-.-	0.17	-.-
F	-.-	-.-	-.-	0.25	-.-	-.-	0.31	-.-	-.-	0.34	-.-	-.-	-.-
TOTAL OXIDES	94.19	99.77	97.63	96.94	95.86	96.05	97.74	99.46	96.66	95.31	96.97	97.79	98.03

Analyst: D.R. Lemkow under supervision of T.S. Ercit, National Museum of Natural Sciences

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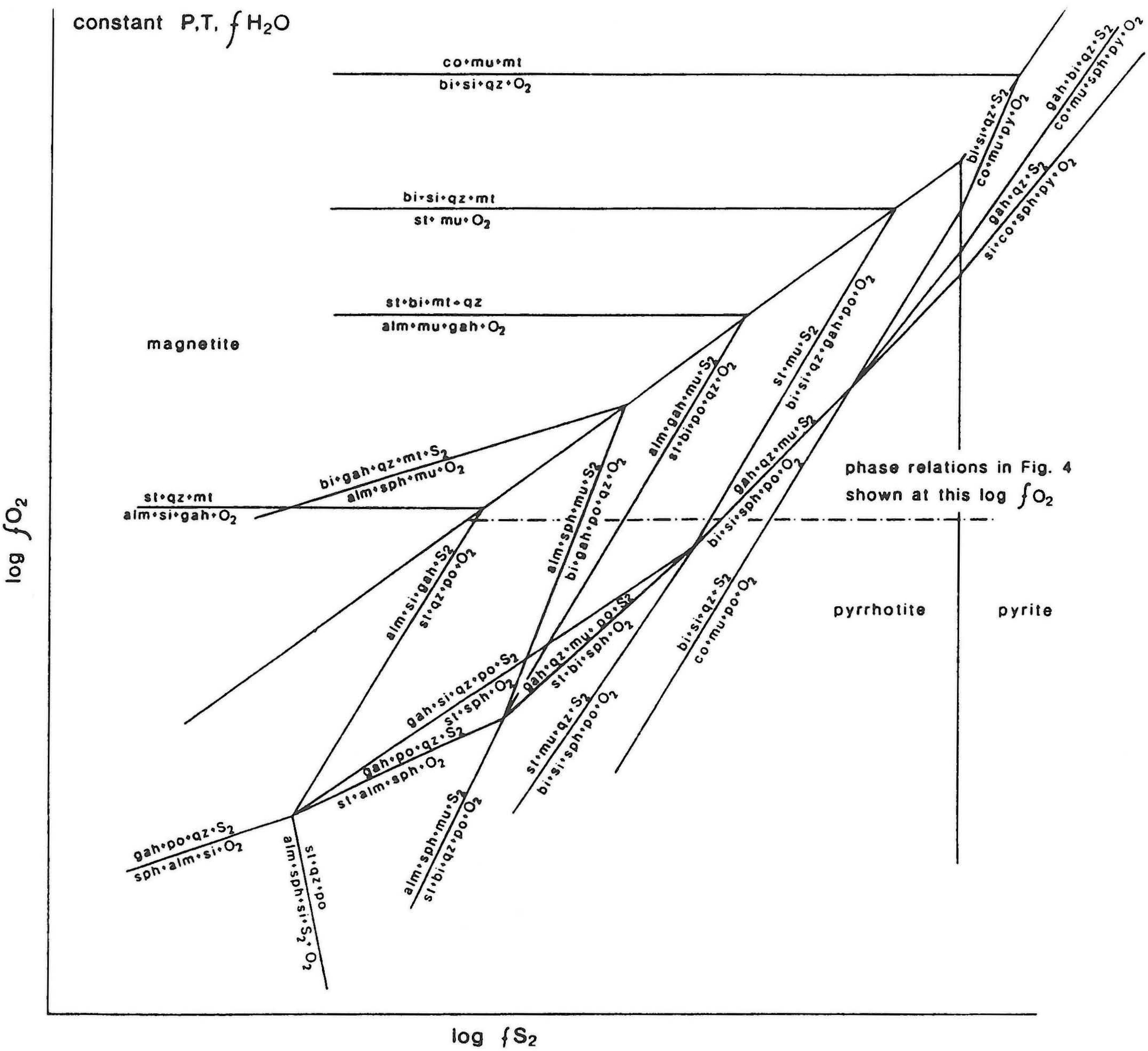

Figure GSC-1-6: *Reaction grid for the system SiO_2-Al_2O_3-FeO- K_2O-H_2O-Zn-O_2-S_2.*

GSC-2 GEOLOGICAL SETTING AND ASSOCIATED ALTERATION OF THE CHISEL LAKE MASSIVE SULPHIDE DEPOSIT, SNOW LAKE, MANITOBA

by A.G. Galley and A.H. Bailes[1]

Galley, A.G. and Bailes, A.H. 1989: Geological setting and associated alteration of the Chisel Lake massive sulphide deposit, Snow Lake, Manitoba; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

Geological mapping of the Chisel Lake deposit at 1:000 scale was undertaken in September, 1988 and June, 1989 to take advantage of excellent exposures created during the development of the open pit mine. Mapping was carried out in conjunction with 1:5 000 scale investigations of the altered footwall stratigraphy to the Chisel Lake mine (Bailes and Galley, this volume). The open pit mapping and 1:5 000 scale mapping are part of a cooperative Geological Survey of Canada - Manitoba Geological Services Branch multi-year project involving detailed mapping of the Snow Lake region massive sulphide deposits and their host-rock stratigraphy. The federal component of the project is part of the multi- disciplinary Exploration Technology (EXTECH) program initiated in 1989 by the GSC. The object of EXTECH is to construct an integrated geoscience database of selected mining camps, and to assist industry in developing new exploration methods for massive sulphide deposits.

The Chisel Lake volcanogenic massive sulphide deposit is 12 km south of the town of Snow Lake, Manitoba. The deposit came into production in 1960, and was the first of seven producing massive sulphide deposits in the region, and one of the two still in operation (Fig. GSC-2-1). The Snow Lake region massive sulphide deposits are hosted by Early Proterozoic Amisk Group subaqueous volcanic and volcanic-derived sedimentary strata. The footwall rocks to six of the deposits has been intruded by two tonalite intrusions, one of which has a U/Pb zircon date of 1889 + 8/-6 Ma (Bailes *et al.*, 1988). Walford and Franklin (1982) postulated that the intrusions are synvolcanic, and acted as heat engines in activating massive sulphide-forming hydrothermal systems.

Amisk rocks and associated base metal deposits have been deformed by east trending isoclinal folds, and subsequently refolded by more open, north-northeast trending folds. The deformational history includes the formation of reverse faults, which have divided the Amisk Group into several fault slices.

LITHOLOGIES AND STRATIGRAPHY OF THE CHISEL LAKE OPEN PIT

Six hundred metres of strongly folded volcanic and sedimentary rocks containing the Chisel Lake deposit are exposed in the Chisel Lake open pit (Fig. GSC-2-2). The tightly folded units strike north-northwest, dip shallowly to the east-northeast, and are truncated along the western margin of the open pit by the Chisel Lake Pluton.

Strong alteration of the footwall stratigraphy makes identification of original lithologies difficult. Lower almandine grade regional metamorphism has produced coarse grained mineral assemblages within the altered rocks thereby allowing a preliminary classification of different alteration types based on their metamorphic mineral assemblage. Isoclinal folding dictates that localities described in the footwall or hangingwall of the orebody be defined by the use of the prefixes 'stratigraphic' or 'structural'.

Powderhouse dacite

The lower 200m of stratigraphic footwall is a plagioclase phyric dacite, composed of tuff, lapilli tuff and subordinate, thin layers of tuff breccia (Fig. GSC-2-2). The dacite consists mainly of fine to coarse grained tuff, in which fragments and matrix are similar in composition. The matrix and fragments are characterized by one to 2mm white plagioclase phenocrysts. The unit coarsens slightly below the massive sulphide lense. Along the east margin of the pit it is massive to finely laminated, with one metre long blocks or boudins of massive, quartz phyric rhyolite.

Ghost Lake rhyolite

Quartz-plagioclase phyric to aphyric rhyolite overlies the dacite, and immediately underlies the massive sulphide deposit (Fig. GSC-2-2). The flows are composed of white lobate bodies of massive rhyolite, monolithic rhyolite breccia and light grey to rusty, recrystallized microbreccia (Fig. GSC-2-3). The section probably consists of more than one flow, as the lower part of the unit is characterized by phenocrysts of quartz (up to 2mm) and plagioclase (1-2mm), and the upper part is aphyric to sparsely plagioclase phyric.

In the stratigraphic footwall, west of the massive sulphide lense, the rhyolite is transected by sulphide veinlets and strongly altered. The strong alteration makes it difficult to distinguish between the rhyolite and dacite along most of this footwall contact.

Massive Sulphide Layer

A 35m thick lense of isoclinally folded massive sulphide exposed in the open pit thins to less than 5m at the contact with the Chisel Lake Pluton, and to less than 1m at the fold hinge that is the southeast limit of the orebody (Fig. GSC- 2-4). The orebody is composed of interlayered bands of coarse grained sphalerite and pyrite. The western half of the orebody contains lenses several metres thick that contain over 80% coarse grained sphalerite, with individual crystals up to 5cm long. The east half of the orebody is typified by massive bands of coarsely granular pyrite. Segments of strongly altered wallrock occur throughout the ore lense; in the fold hinge that represents the southeast termination of the ore there is a thin, segmented bed of laminated chert (Fig. GSC-2-5).

A 1 to 2m thick unit of finely laminated cherty rock interlayered with bands of pyrite and sphalerite (Fig. GS-2- 6) occurs at the contact between the rhyolite flows and the mafic volcaniclastic hangingwall unit. This unit, which is the lateral extension of the massive sulphide lense, is truncated by a gabbro dyke, but reappears sporadically along the margin of the gabbro as finely banded siliceous, sulphide- rich sediment. This sulphide-rich sedimentary unit grades down-dip into a thin layer of massive sulphide at the 250 level of the mine, that continues down through the 650 level to become an orebody several metres wide and 60 metres long (J. Stephens, pers. comm.).

Within the immediate stratigraphic footwall of the massive sulphide lense there are several zones containing abundant veins of sphalerite and pyrite. These zones of lower grade stringer ore can be traced around the nose of the folded massive sulphide lense into the structural hangingwall of the orebody, where they are chalcopyrite-pyrrhotite rich. The stringer zone is truncated by the Chisel Lake Pluton, but reappears as sphalerite-chalcopyrite stringers within the altered rhyolite fragmental rocks surrounding the rhyolite flow lobes 100m to the east of the massive sulphide lense.

Chisel Basin mafic volcaniclastic rocks

Mafic volcaniclastic rocks that overlie the orebody consist of interlayered, finely laminated mudstone and fine grained wacke that grade up section into more massive, fine grained wacke. Layers of breccia 1 to 3m thick, with angular rhyolite fragments, occur up to 40m above the rhyolite contact. Along the northeast corner of the open pit the unit is composed of interlayered mafic breccia and finely-laminated wacke.

Gabbro

Supracrustal rocks are cross-cut by fine to medium grained, aphyric gabbro dykes, which can be over 100m wide. The margins of the intrusion are very fine grained and flinty, whereas the core of the wider sections of dyke have a medium grained, subophitic texture. The gabbro has no internal contacts or layering; it is overprinted by an alteration mineral zonation described in a later section of this report.

Plagioclase Porphyritic Mafic Dykes

Several plagioclase porphyritic dykes 30 to 40cm wide cross- cut

[1]Manitoba Geological Services Branch

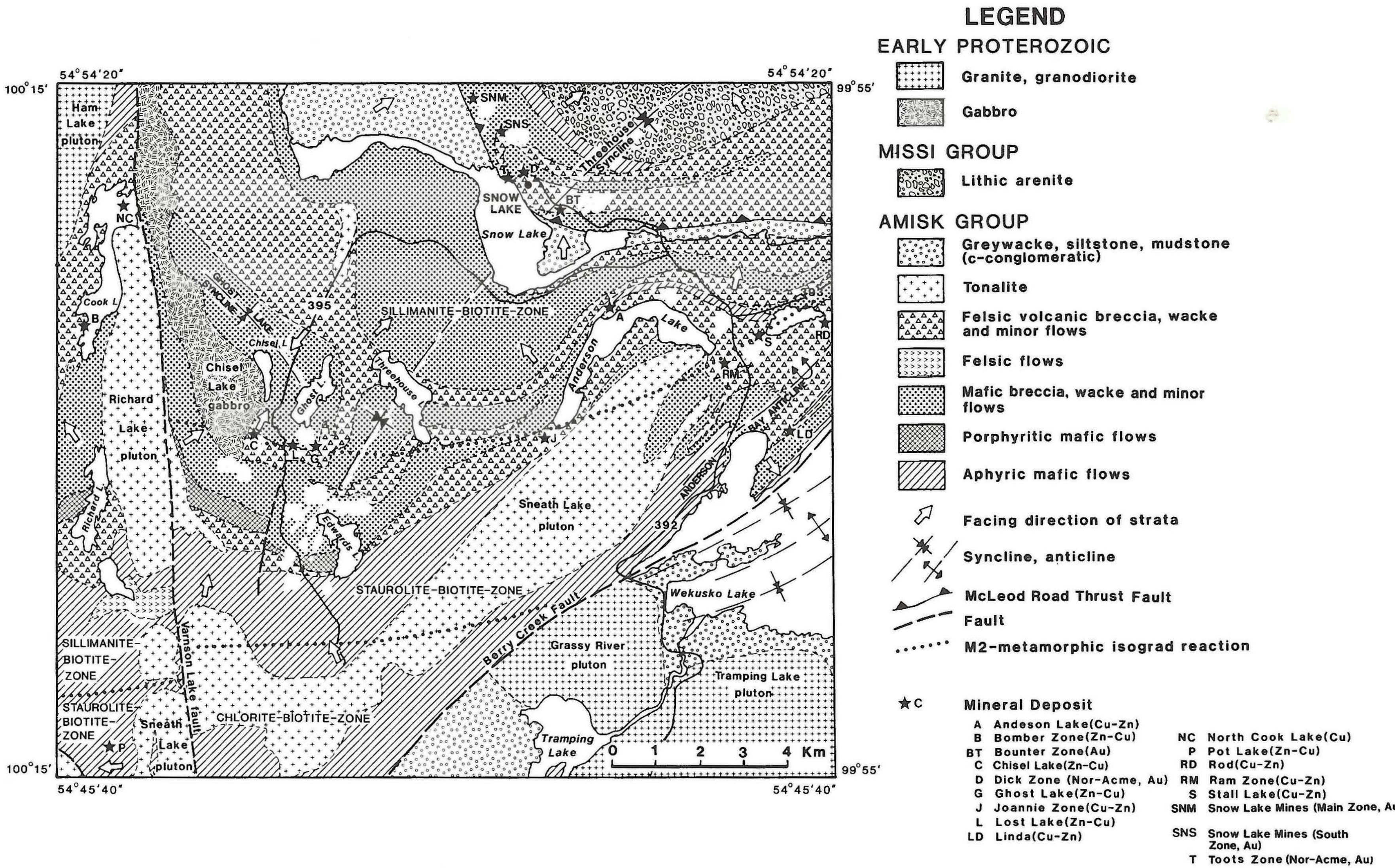

Figure GSC-2-1: *Geological setting of massive sulphide deposits in the Snow Lake area (from Bailes et al., 1987).*

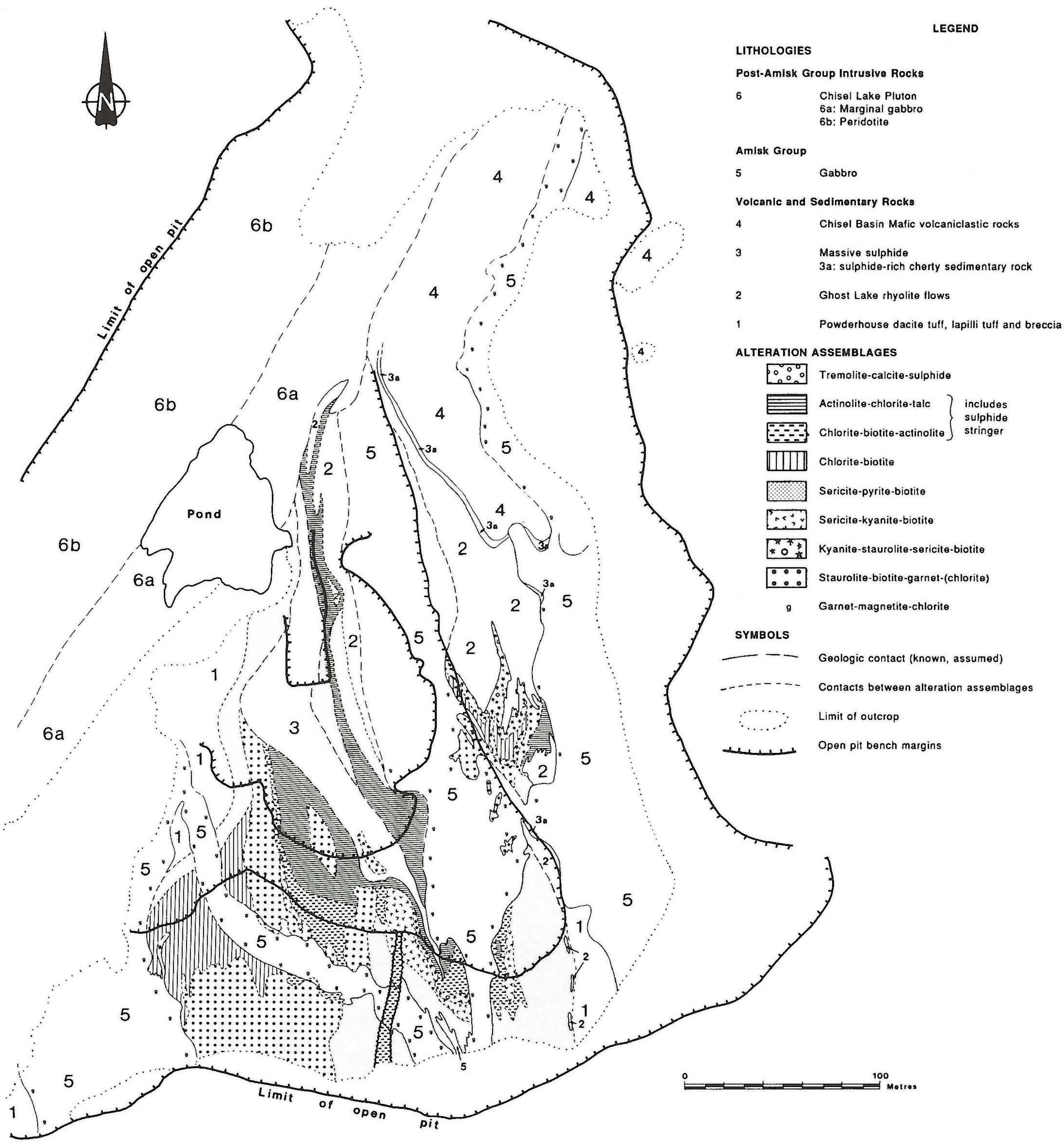

Figure GSC-2-2: Lithological and alteration assemblage map of the Chisel Lake open pit.

Figure GSC-2-3: *Lobate body of massive rhyolite (white) in felsic flow, structural hangingwall of the massive sulphide lense.*

previously described rock types. These straight, thin dykes can be followed intermittently for over 100m, generally parallel the north-northwest striking penetrative foliation. They commonly display a well-defined pinch-and-swell fabric, with up to 5m between boudins.

Chisel Lake Pluton

The steep west wall of the open pit is composed of two phases of the Chisel Lake Pluton. The margin of the pluton consists of up to 60m of coarse-grained, amphibolitized gabbro, followed to the west by coarse-grained peridotite. The gabbro is massive, and truncates the isoclinally folded units. Where the gabbro cuts the massive sulphide lense, it contains 3 to 5% fine- to medium-grained chalcopyrite in veinlets and fractures within the intrusion for up to 15m from the contact. This sulphide-rich gabbro is presently being analyzed for PGEs.

ALTERATION ASSOCIATED WITH THE CHISEL LAKE OREBODY

Nine alteration assemblages have been identified, eight of which are restricted to the stratigraphic footwall of the massive sulphide layer (Fig. GSC-2-2). The eight footwall mineral assemblages define alteration zones that are crudely concentric about one another. Contacts between zones are commonly diffuse over tens of centimetres, with the contacts defined by the first appearance or disappearance of a characteristic metamorphic mineral. Cross-cutting relationships between alteration zones are relatively consistent and define an order of increasing intensity typified by a progressive loss in the original textures of the footwall rocks.

Sericite-rich alteration forms a halo about the other zones. Within this halo staurolite-rich alteration is overprinted by a kyanite-rich zone that is overprinted by chlorite and amphibole-rich alteration zones. The chlorite-amphibole alteration is further characterized by abundant sulphide veins that define the footwall stringer ore. The footwall alteration zones are collectively over 200m wide, merging near the south margin of the pit with a regional-scale alteration described by Bailes and Galley (this volume).

The margins of the gabbro dyke in both the stratigraphic footwall and hangingwall are typified by up to 10% pinhead- sized garnets. Within 3m of the margins the gabbro becomes chlorite-rich, with 20% garnets up to 7mm and 1 to 2mm magnetite grains. Where cooling fractures are observed in these contact zones, they are commonly replaced with massive garnet veins 5mm to 1cm wide. In the stratigraphic footwall to the mas-

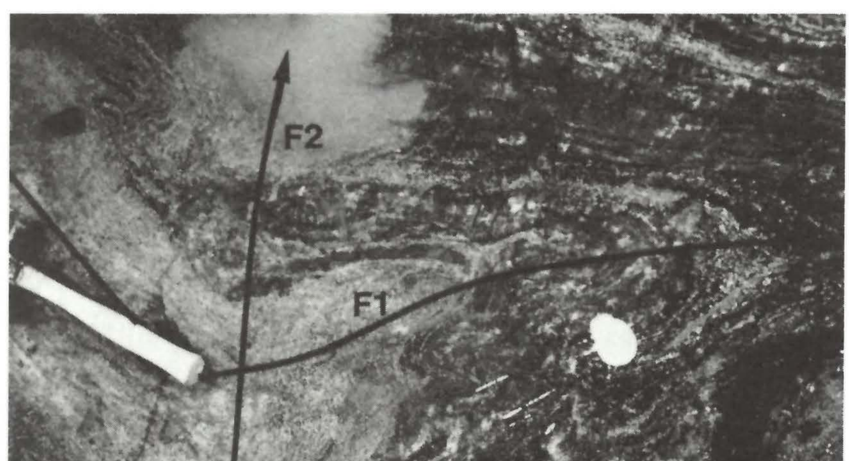

Figure GSC-2-4: *Isoclinal F_1 fold terminating the southeastern end of the massive sulphide lense (MSL). The sulphide lense has been subsequently folded about an open F_2 structure.*

Figure GSC-2-5: *Rootless F_1 fold nose (arrow) composed of laminated chert within the massive sulphide lense. Pencil magnet aligned along trend of F_2 folds.*

sive sulphide horizon the gabbro dyke is crisscrossed by abundant, irregular amphibole veinlets and planar quartz-amphibole veins; both have irregular haloes of bleached wallrock.

Small dykes of gabbro are recognized within the amphibole alteration zone in the structural footwall to the massive sulphide lense where they are altered to actinolite-chlorite- talc. Where in contact with the biotite-staurolite-garnet alteration the margins of the gabbro contain 1 to 2cm elongate, euhedral staurolite crystals, with 5mm to 1cm garnets.

STRUCTURE

Two fold phases are recognized in agreement with Martin (1966): the first phase (F_1) is characterized by a strong, axial planar, penetrative chlorite-biotite foliation (S_1) that strikes 350° to 330° and dips 45 to 85° to the east (Fig. GSC-2-7). The F_1 isoclinal folding has significantly shortened the stratigraphy into a large S-shaped structure and structurally thickened the massive sulphide lense. A series of rootless folds formed from thin chert layers associated with the massive sulphide lense plunge moderately to the north-northwest, subparallel to the axial planar foliation. A fold with a similar orientation is observed in the chlorite-actinolite-talc alteration in the immediate stratigraphic footwall, where the trace of an F_1 fold axis is defined by coarse-grained precious metal-rich galena veins.

A second foliation (S_2) kinks the S_1 foliation into moderately NNE plunging folds. The S_2 foliation strikes 020°, dips steeply southeast, and is defined by the orientation of biotite and a slight elongation of volcanic fragments, which parallel the plunge of the orebody at an azimuth of 020°, plunging 45°. The F_2 event is further typified by a series of slightly boudinaged, planar quartz-pyrite-sphalerite veins that cross-cut massive rhyolite and neighbouring gabbro parallel to the S_2 foliation.

CONCLUSIONS

Preliminary investigations of the geology exposed in the Chisel Lake open pit mine have shown that:

a) The orebody is underlain by massive rhyolite flows and fragmental rocks and overlain by well-bedded mafic volcaniclastic strata. The association of massive sulphide deposits with rhyolite complexes is documented at the Ghost deposit (Bailes, 1987) and at the Anderson and Stall deposits (Walford and Franklin, 1981). The recognition that rhyolite eruption represents a period in the volcanic cycle in which massive sulphide deposits are commonly formed has been noted in many major base metal camps (Franklin *et al.*, 1981).

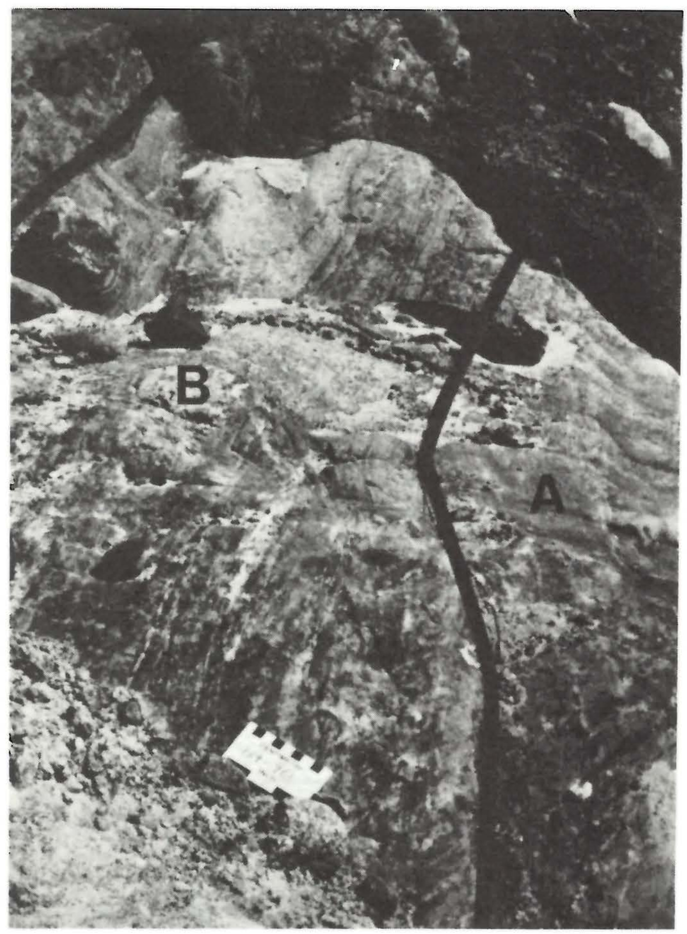

Figure GSC-2-6: *Laminated chert-sulphide layer (B) at contact between rhyolite flow (A) and laminated mafic volcaniclastic strata (C).*

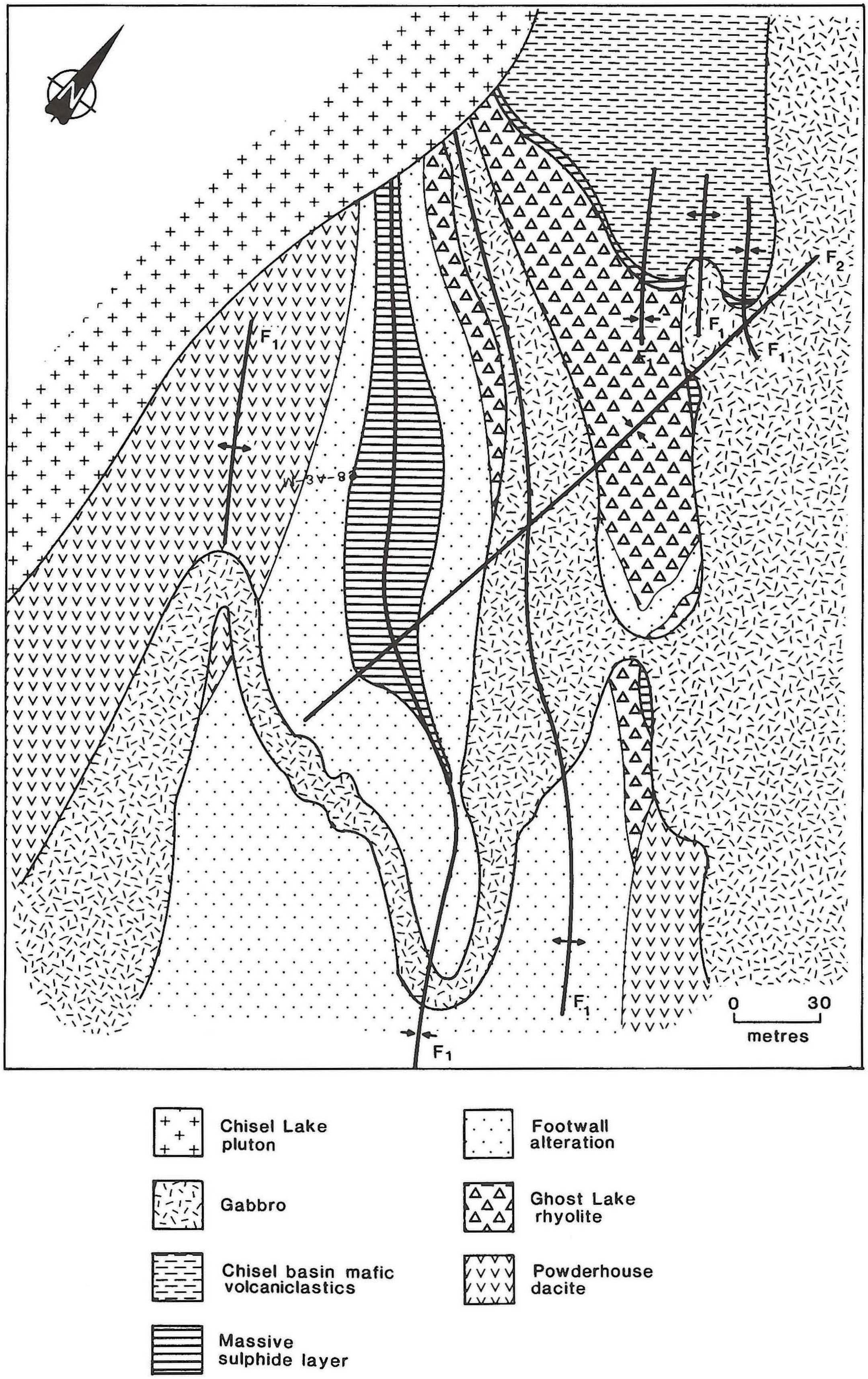

Figure GSC-2-7: *Schematic diagram of fold pattern within the Chisel lake open pit.*

b) The andesites mapped by Martin (1966) are gabbro dykes that crosscut the deposit stratigraphy. The recognition of this rock type as a crosscutting feature will simplify the understanding of this complexly folded sequence.

c) Alteration is restricted to the stratigraphic footwall of the massive sulphide lense, and can be divided into a number of mineral assemblages to form a classic alteration pipe (Lydon, 1984) in which there are potassic-, iron-magnesium-, aluminum- and magnesium-rich zones. Recognition of this internal zonation will assist exploration geologists in defining the relative position of observed alteration mineral assemblages with respect to the fossil rock-seawater interface and possible massive sulphide deposits.

d) Isoclinal folding has significantly shortened stratigraphy in the vicinity of the Chisel, Lost and Ghost deposits. It is possible that there are folded sections of the stratigraphy between these deposits that have not been fully explored.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the close cooperation and assistance of Frank Bill and Jack Stephens of Hudson's Bay Mining and Development Co. Ltd. These geologists not only allowed free access to the open pit and underground data from the Chisel Lake deposit, but also provided logistical assistance during the field season.

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GSC-3 TRACE ELEMENT CHARACTERISTICS AND CONTROLS OF ELEMENT MOBILITY IN THE METASOMATIC AUREOLE TO THE TANCO PEGMATITE.

by N.M. Halden[1], R.E. Meintzer[1], P. Cerny[1]

Halden, N.M., Meintzer, R.E., and Cerny, P. 1989: Trace element characteristics and controls of element mobility in the metasomatic aureole to the Tanco pegmatite; **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The principal objective of this study was to establish the geochemical characteristics of the alteration halo surrounding the Tanco pegmatite, with a view to determining which element or combination of elements could be used for geochemical exploration for rare-element pegmatites and to suggest potential chemical and structural controls on the mobility of elements and the scale of the aureole. The study also aimed to determine; i) the viability of using a standard, commercially available, analytical package in achieving this goal, and ii) whether or not partial acid digests, as part of the analytical scheme, would lead to significant improvements in the definition of an anomaly.

The rocks hosting the Tanco are dominated by mafic amphibolites, but include metagraywackes and some granitic and pegmatitic stringer veins. Samples were taken from a broad a range of rock types along sections at right angles to the body, as well as from a section along the length of the pegmatite body. A total of 380 samples were retrieved from drill core for multiacid digestion and analysis; while 100 of these samples were also subjected to partial acid digest and analysis. The samples were analyzed by the Ottawa laboratory of Bondar-Clegg & Co., Ltd., using their ICP-Atomic Emission Spectroscopy analytical package.

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SAMPLE SELECTION

Samples were derived from thirty-one drill holes along an E-W longitudinal section (Tanco Mine section 9,700N) and a N-S cross-section (section 10,200E), shown in Figure GSC-3- 1. Sampling above the main pegmatite was conducted at intervals of 5, 10, 17, and 25 feet and thereafter at 25 foot intervals along the drill hole from the pegmatite/wallrock contact (Fig. GSC-3-2). These intervals were adjusted to exclude extensive alteration, veining, missing core, or minor changes in lithology. Samples within the first foot of the pegmatite, typically within the Wall Zone were also taken for analysis; these samples were not used in the gridding and contouring operations. Samples consisted of 15 cm lengths of core.

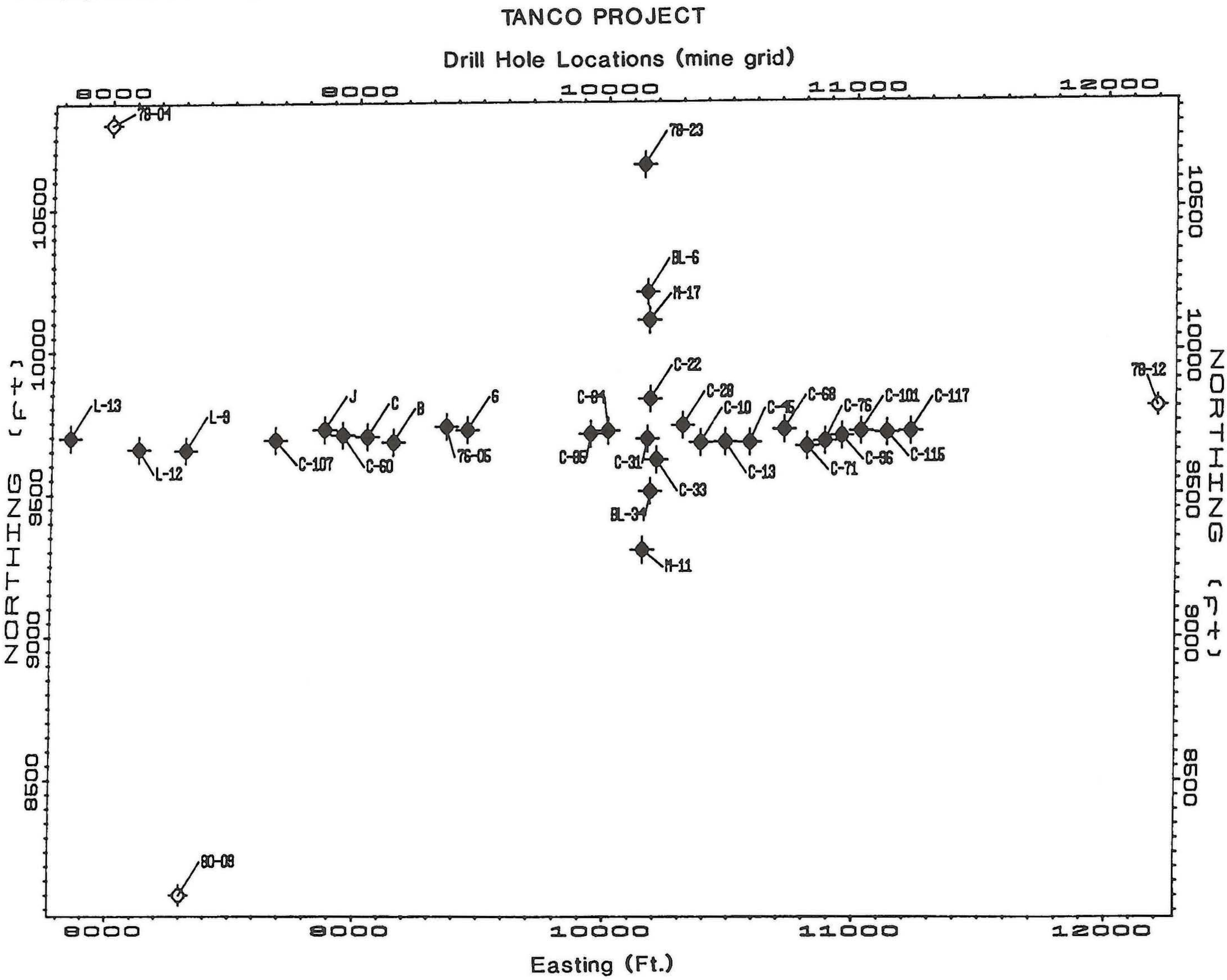

Figure GSC-3-1: Relative positions of drill holes on the N-S and E-W sections. Drill hole identification corresponds to Tantalum Mining Corporation labels.

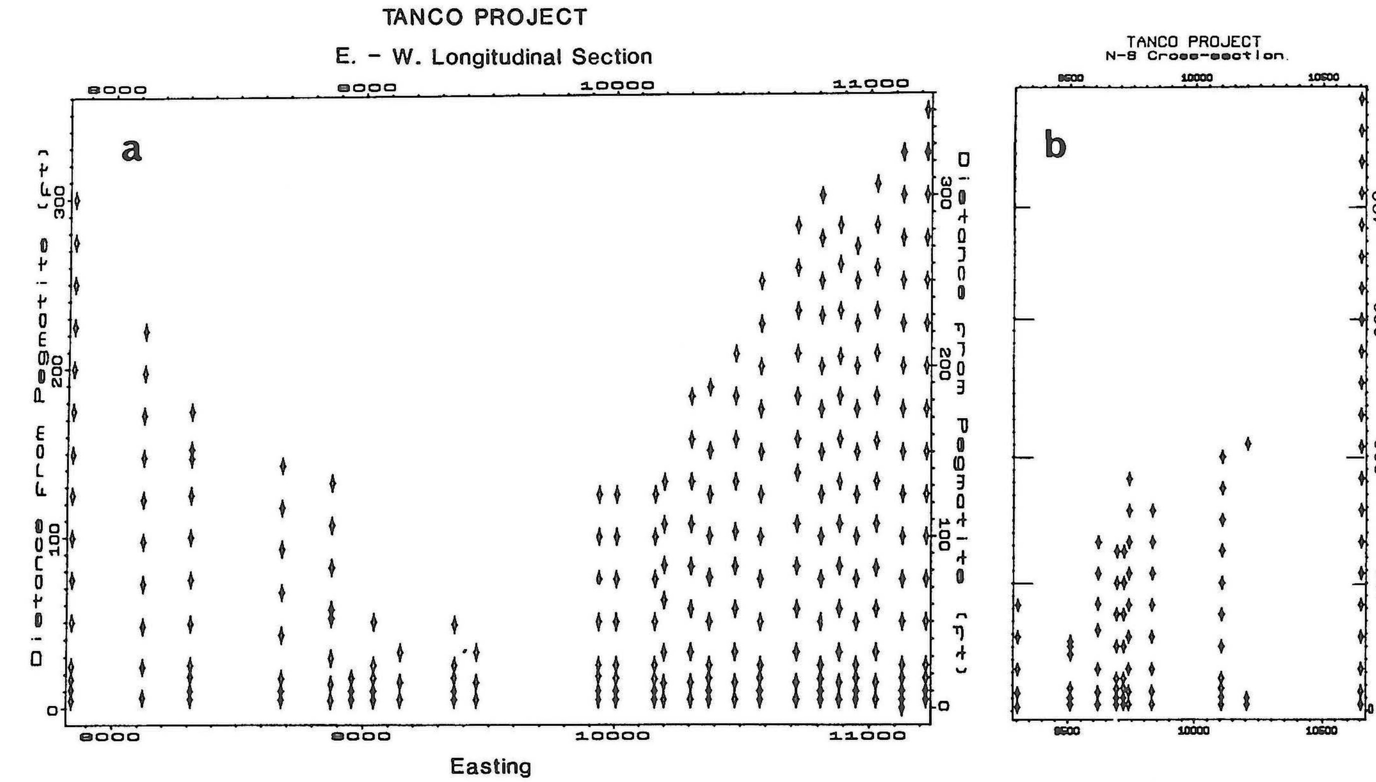

Figure GSC-3-2: *Sample locations along drill holes. a) E-W section, pegmatite is closest to the ground surface in the centre of the section; b) N-S section, pegmatite is closest to the ground surface on the left of the section.*

Samples were also taken at 25 foot intervals from three drill holes 240 m to 340 m distant from and not intercepting the Tanco pegmatite. These samples were selected to ascertain mean background elemental values and the range for each element analyzed.

ELEMENT SELECTION

The selection of elements for analysis was to some degree determined by the types of analytical packages that are commercially available. It was concluded that as broad a range of elements as possible would yield the best chance of defining anomalous element(s) concentrations. It was, however, recognized that elements most likely to yield the best results would be the alkali metals as they are concentrated within the pegmatite, and are most likely to be mobile in an aqueous fluid associated with the pegmatite (c.f. Morgan and London 1987; Gaupp *et al.* 1984). Because of the range of samples taken, and the wide range of elements being analyzed, there was the possibility of not only searching for positive anomalies associated with the introduction of element, but also negative anomalies that would be consistent with element(s) having been leached from the amphibolites. The analytical package chosen was the ICP- Atomic Emission Spectroscopy (Group 1) package of Bondar- Clegg & Co., Ltd. Using a multi-acid dissolution (HF-$HClO_4$- HNO_3-HCl), this package offered a broad range of elements[2] with lower limits of detection ranging between 0.2 and 20 ppm. Actual lower limits of detection achieved in light of interelement interference ranged upwards to 50 ppm. In addition, splits of 100 randomly selected samples were also analyzed using a partial digest by LeFort aqua regia (HCl- HNO_3 1:3) for purposes of comparison with the more expensive multiacid method of digestion (Meintzer *et al.*, 1989)

STATISTICAL ANALYSIS AND PLOTTING

The analytical data was gridded and contoured with "GRIDZO"[3], a commerically available contouring and gridding program available from RockWare, Inc. This software program offers a variety of gridding algorithms including inverse-distance, polygon-fit and triangulation. The inverse-distance algorithm using a radial search routine with eight nearest neighbours[4] was used to generate a grid[5] from the geochemical data. Contours were generated using absolute element abundance and by a factor of mean background; the latter technique offering a more rapid quantitative estimate of the significance of an anomaly. As geochemical trends were desired, contours were not forced to honor control points and a series of mathematical smoothing routines were applied to the raw contours.

RESULTS

A number of elements clearly showed values considerably elevated above background within the wall-zone of the pegmatite (Meintzer *et al.*, 1989). Excluding the wall-zone as being a narrow lithologically distinct region, and concentrating upon what might be anomalous element concentrations outside this zone, considerably reduces the number of elements that seem to demonstrate anomalous concentrations and/or distribution. The elements that show the most significant elevation above background and anomalous distribution are Li, Rb and Sn.

LITHIUM

Elevated values of lithium, up to 45 times background are seen throughout the sections examined (Fig. GSC-3-3a, 3-3b). The actual extent of the anomaly cannot be determined, but it extends a minimum of 300 ft (above the body) from the contacts of the pegmatite. This can be observed at eastern end of the longitudinal section (Fig 3a), where about 300 ft of amphibolites are cut by drill holes; C-101, C-115, and C- 117 (Fig. GSC-3-1, 3-2); before an intersection is made with the pegmatite body. The most intense anomaly coincides with a 5-10 ft pegmatite stringer which occurs about 120 ft above the main pegmatite. Li values above back-

[2]Ag, As, B, Ba, Be, Bi, Cd, Ce, Co, Cr, Cu, Ga, La, Li, Mo, Nb, Ni, Pb, Rb, Sb, Sc, Sn, Sr, Ta, Te, T1, V, W, Y, Zr, Zn

[3]Version 4.02

[4]Where $z' = (``(z/d^2))/(``(d^{-2}))$; z' = value of grid cell, z = value of point, d = distance from cell center

[5]A constant grid of 135 ft. (horizontal) by 18.75 ft. (vertical) was used in all sections

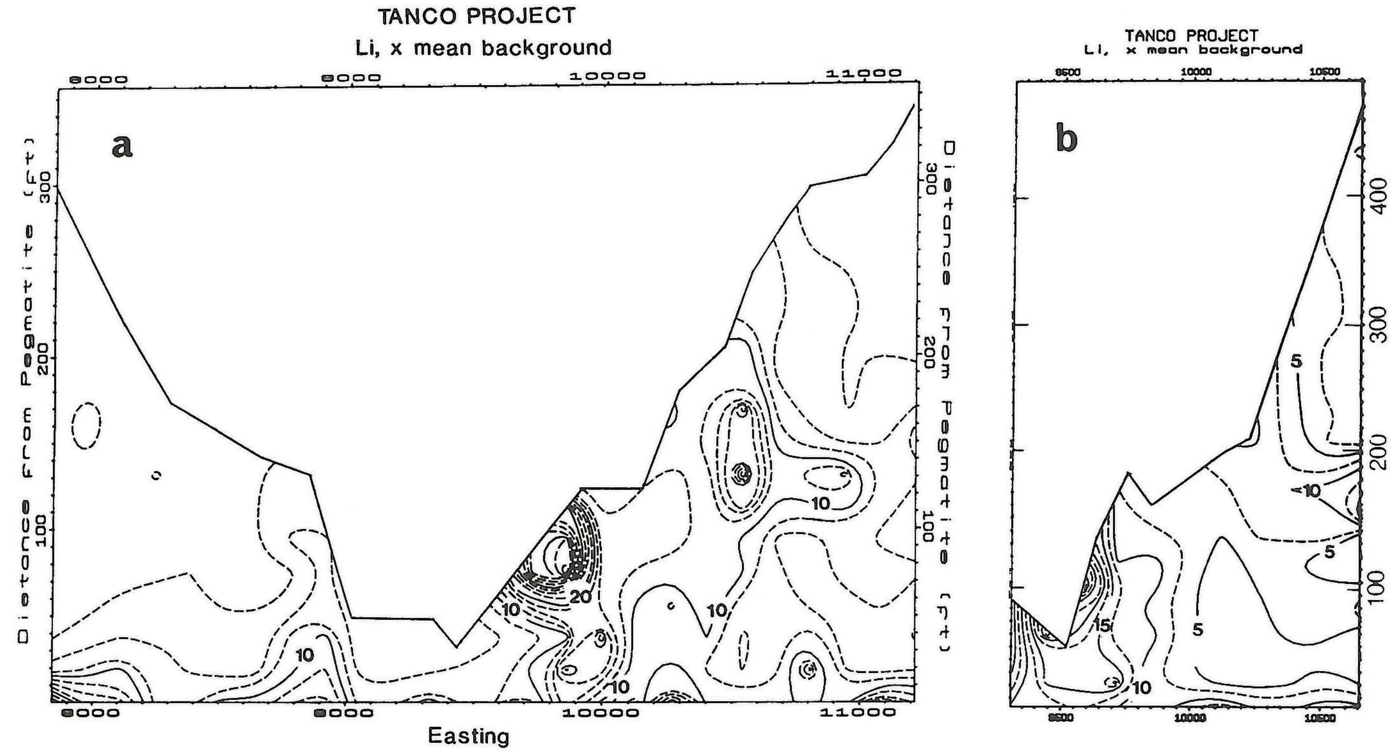

Figure GSC-3-3: Location of Li anomalies in the E-W section (a) and the N-S section (b). Contour intervals are factors of mean background (27 ppm).

ground correlate with thin pegmatite and granitic veins and shear zones which lie above the body. The majority of these veins and shear zones strike approximately N-S and dip shallowly (about 15-20°) east and west. They are probably related to a regional stress environment which is in itself reflected in the overall shape of the main pegmatite bodies. The veins and shears are likely to have exploited a joint system that acted as the locus of fluid movement during metasomatism associated with pegmatite emplacement.

In contrast to what appears to be a clearly focused fluid movement observed in the E-W section, the Li anomaly is not as well expressed in the N-S cross-section. The N-S section is at a high angle to the regional E-W, steeply dipping foliation in the host amphibolites. In this case, although the existence of the foliation might have been expected to impart an anisotropic permeability to the amphibolites it does not seem to have had a major influence on fluid movement associated with the pegmatite intrusion.

RUBIDIUM

The distribution of rubidium (Fig. GSC-3-4) is broadly similar to that of lithium and it is likely that the same structural controls have influenced its movement. However, the high detection limit (50 ppm) offered by the analytical package as a result of interelement interferences has resulted in a more subdued and dispersed expression of the anomaly. It is likely that if the detection limit were significantly lowered then the gradient of concentration changes would be more pronounced leading to a more tightly constrained anomaly.

TIN

Tin values about two times background suggest that there are anomalous regions within the amphibolite that seem spatially associated with pegmatite veins and proximity to the wall- zone. The expression of the anomalies is much more subdued in comparison with those of the alkali metals. In addition, the elevated values are restricted to within 20 ft of the wall- zone and pegmatite veins.

OTHER ANOMALIES

The only other significant positive anomalies observed in the section were some very tightly constrained regions showing concentrations of Cu, Zn and Ni. These can probably be correlated with the distribution of accessory sulphides in the amphibolites.

The possibility that the metasomatic aureole could also have an expression as a zone of elemental depletion is unlikely. The data suggests no clear patterns of elemental depletion. It is possible that the expression of such an anomaly (if such a feature existed) could be larger than the region examined.

No effort was made to contour the limited data derived from the partial digests. Examination of the data (Meintzer *et al.*, 1989) reveals that only limited extraction of the elements was achieved. For example, the mean difference in Li concentration between the two sets of samples is 122 ppm (s = 186 ppm) and Sn exceeded the detection limit in only two samples in those in the partial digest group.

SUMMARY

The distribution of elements within a metasomatic aureole surrounding an igneous intrusion will be a function of the interaction of a number of geological characteristics associated with the host rock, the intrusion and the fluid associated with the alteration event. Host rock characteristics including mineralogy, foliation, and the distribution of stress (strain features include joints and shear zones) are likely to influence the shape and spatial extent of the dispersion pattern associated with fluid movement. The geochemical characteristic of the intrusion itself will govern what elements are likely to be present in migrating fluids in sufficient quantities to react with the country rocks and be detected above the normal ambient background for that element. The nature of the transporting fluid is likely to be the most difficult feature to constrain in terms of extensive and intensive thermodynamic variables.

London (1984) and Morgan and London (1987) have described the influence of the log f_{HF}/f_{H_2O} value, for the transporting fluid, on the mobility of elements such as K, Rb and Cs. The chemical activities of such anions as Cl and F will have marked influence on the Eh and pH of the transporting fluid. Aqueous solutions associated with pegmatites are thought to have pH values less than 5. Under such conditions it might be expected that the solubility, and hence mobility, of a large range of elements would be enhanced.

This does not seem to be the case, as no anomalous values or spatial distributions for elements such as Ta and Nb (or rare- earth elements)

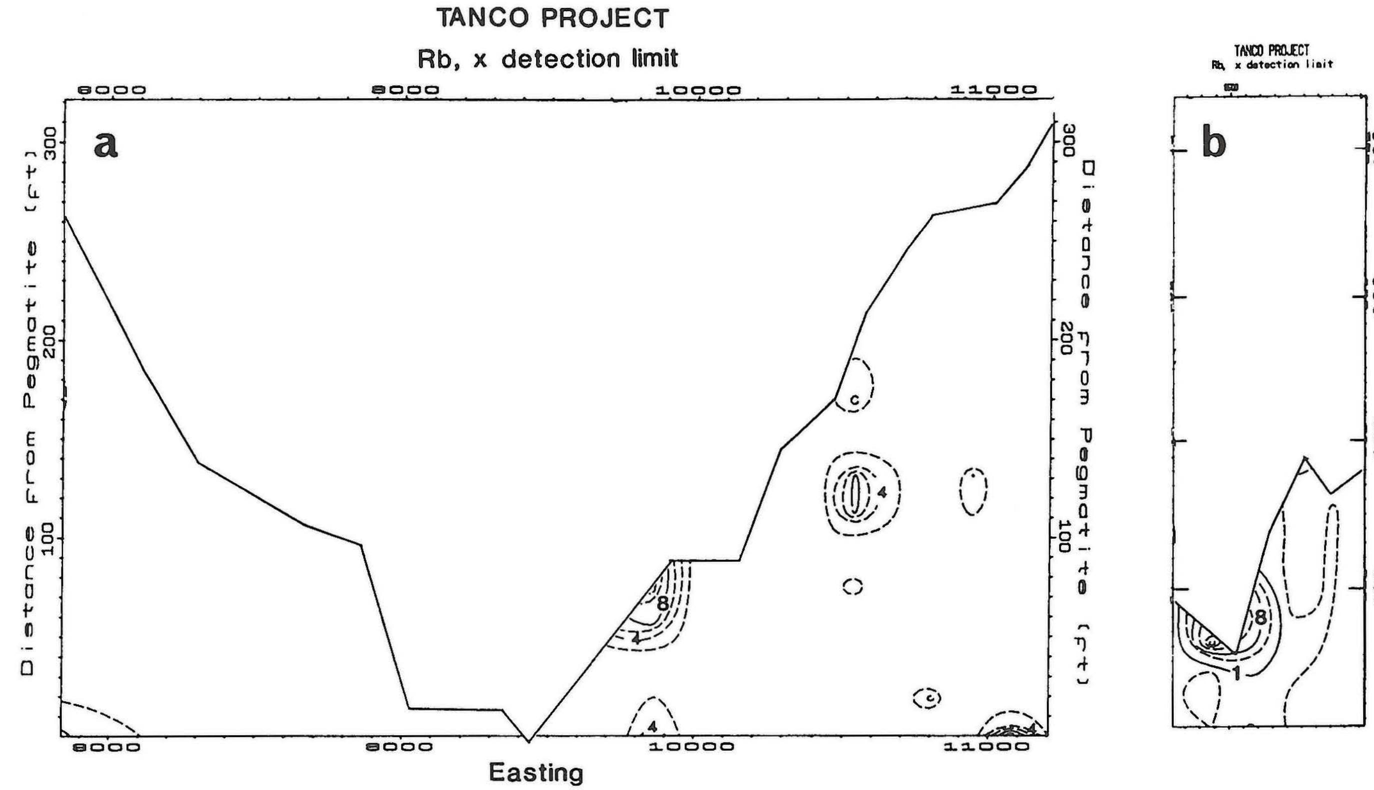

Figure GSC-3-4: *Location of Rb anomalies in the E-W section (a) and the N-S section (b). Contour intervals are factors of detection limit (50 ppm).*

were observed. It is only Rb and Li from a wide range of elements that seem to express any sort of dispersion halo in the present case study. Although the Tanco pegmatite is enriched in Ta and Nb, the oxides of these and the other HFSE are stable under a wide range of pH and Eh fluid conditions. Obviously the mobility of Nb and Ta would be useful clues to the existence of Nb,Ta-enriched deposits, and their presence (if mobile and reactive) would be easily detected above background levels. However the conditions in terms of fluid chemistry that would be required to make them mobile are extremely restricted, requiring in the case of Nb a pH of 1 (c.f. Brookins 1988).

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MINES BRANCH
EXPLORATION SERVICES

ES-1 MANITOBA'S PRECAMBRIAN DRILL CORE COLLECTION PROGRAM AN UPDATE AND REVIEW

by D.E. Prouse

Prouse, D.E. 1989: Manitoba's Precambrian drill core collection program, an update and review; in Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION AND HISTORY

The Manitoba Mines Branch realizes that retrieved exploration drill core is a valuable data source that can be utilized by explorationists in their search for mineral prospects, and by researchers in their scientific endeavors. For this reason the province has been retrieving and storing Precambrian drill core since the early 1970's. Prior to 1970, the province collected drill core largely as an aid to specific research projects.

In the early 1970's, a core collection program was started to assist exploration companies and prospectors in the province. The construction of core sheds at The Pas (1972), Thompson (1973), and Lynn Lake (1974) provided storage space that allowed for a concerted effort towards core collection. The acquisition of storage space in 1980 for core from southeastern Manitoba meant that there was a core storage facility for drill core collected and donated from companies carrying out drill programs in the major greenstone belts in Manitoba. As a result, the initial small scale core collection program has evolved into the present day Precambrian Drill Core Library System, which currently holds approximately 1 900 drill holes totalling 180 000 metres of core.

Precambrian drill core collection has been the responsibility of various Energy and Mines personnel. From 1971 to 1977, it was the responsibility of the Resident Geologist in The Pas. When the Resident Geologist position was discontinued in 1977, core collection was administered by various Mines Branch employees, or core was delivered to core storage facilities by exploration companies. By the end of 1982, 88 600 metres of drill core had been collected. However, due to limited staff during the 1970's, much of this core was not properly inventoried nor was it stored in an organized manner.

In January 1983, the province's core program was reactivated. Departmental staff, with the aid of assistants hired through the Thompson Job Creation Program added 24 000 metres of core to the library system and major reorganizations of core shed inventories were initiated.

In April, 1984, the Governments of Canada and Manitoba embarked on the Canada-Manitoba Mineral Development Agreement(MDA). Under the terms of this five year Agreement $24.7 million was allotted for activities that were key to strengthening Manitoba's mineral industry. A portion of the MDA funds were allocated to Manitoba's Precambrian Drill Core Libraries Program.

Approximately $631 000 was spent on capital and operating costs for the Precambrian Drill Core Library System. A total of approximately 80 000 metres of core were collected and added to this system and about 58 000 metres of core were discarded or reduced.

Industry and public use of the core library program facilities and services increased during the early years of MDA (Fig. ES-1-1); however, use has declined since fiscal year end 1987-88. An open file report containing a listing of Precambrian drill core held in the provinces' storage facilities is in final stages of preparation. The format of this listing will simplify locating core and determining what holes a user wishes to view. This it is hoped will encourage users to utilize the service provided by the library

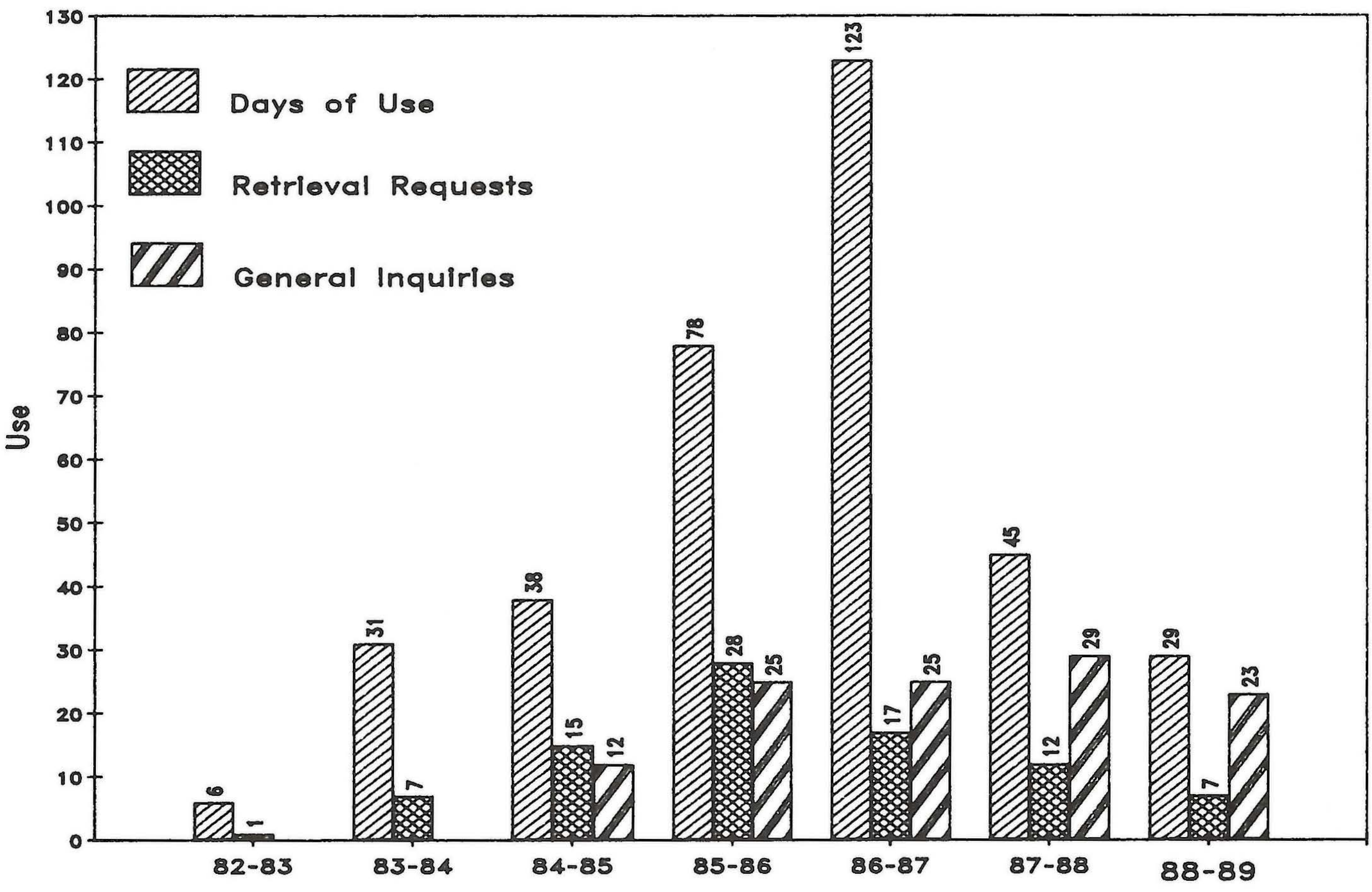

Figure ES-1-1: Use of core library system.

system.

The Mineral Development Agreement expired on April 1, 1989. Subsequently, funding for the drill core program has been reduced and the program has been down sized accordingly.

PROJECTS COMPLETED UNDER THE MDA

During the term of the MDA a number of projects were successfully completed resulting in upgraded facilities and services provided by the Precambrian Drill Core Libraries Program. A brief summary of these projects are as follows.

Year I (1984)

The construction of a new wing on the core library in The Pas expanded the holding capacity by 300%. Core retrievals added 26 000 metres of core to the provincial core library system.

Year II (1985)

Selective reduction of specific holdings to increase library storage capacities and compilation of a master file system for all holdings within the libraries were conducted. Core retrievals added 34 000 metres of core to the system and 12 000 metres of redundant core were discarded.

Year III (1986)

Construction of new inside and outside storage racks in Thompson and new outside racks in Lynn Lake increased storage capacity for these facilities. 8 000 metres of core were collected and 39 000 metres were discarded.

Year IV (1987)

Development of a computer-based master inventory was initiated and completed for the 3 northern core libraries. Core retrievals added 4 500 metres to the system and 2 000 metres of core were discarded.

Year V (1988)

Drill core stored outside the Winnipeg facility was moved inside to sheltered storage. Gathering of data to prepare an open file listing of all core within the library system was started. 7 000 metres of core were collected and 5 000 metres were discarded.

1989 PROGRAM

New racks for approximately 32 000 metres of core were constructed inside the Brady Road facility in Winnipeg. This core was inventoried, reorganized and placed in the racks. When space becomes available plans are in place to double the core rack capacity for this facility. Data entry of the Winnipeg core inventory into computer files is proceeding.

Work continued on the preparation of an open file listing of core holdings in the Precambrian Drill Core Library System. Target date for report distribution is December.

Core inventory in The Pas library increased by 45 new drill holes totalling 3 928 metres of core. Building maintenance was carried out and a new rock saw for cutting core was installed. In Lynn Lake, 8 new drill holes totalling 1 617 metres were added to the inventory holdings (Fig. ES-1-2). Thompson library inventory increased by one hole 286 metres in length. In Winnipeg, 7 new drill holes totalling 335 metres were added to the inventory. As of September 1, 1989, the provincial core storage system had increased in 1989 by 61 holes totalling 6 166 metres of core.

PRESENT CORE HOLDINGS IN CORE LIBRARIES (Fig. ES-1-3)

The four libraries currently hold 179 593 metres.

Table ES-1-1
DRILL CORE LIBRARIES HOLDINGS

Library Location	Present Inventory	% Capacity Utilized
Lynn Lake	45 378 m.	59
Thompson	31 552 m.	53
The Pas	73 300 m.	45
Winnipeg	29 363 m.	91

Figure ES-1-2: Government core retrieval, Lynn Lake area, July, 1989.

HOW TO USE MANITOBA'S CORE LIBRARIES

The four core libraries have well lit, heated inspection rooms, and core splitters are provided. A rock saw for cutting core has been installed in The Pas library.

Department core libraries are not permanently manned, therefore enquires and permission for access must be made to:

D. Prouse, Resident Geologist
Mines Branch - Exploration Services Section
Manitoba Energy and Mines
Provincial Building, Third and Ross Avenue
The Pas, Manitoba R9A 1M4
Phone: (204) 623-6411 ext. 251
OR
B. Esposito, Assessment Geologist
Mines Branch - Exploration Services Section
Manitoba Energy and Mines
555 - 330 Graham Avenue
Winnipeg, Manitoba R3C 4E3
Phone: (204) 945-6535

Permission to access the Lynn Lake or Thompson libraries, for viewing only the non-confidential core, must be granted by Mr. Prouse or Mr. Esposito who will make appropriate arrangements with local Government representatives on behalf of the user.

The representatives are:

Lynn Lake: Conservation Officer
Manitoba Department of Natural Resources
675 Halstead Avenue
Lynn Lake, Manitoba R0B 0W0
Phone: (204) 356-2413

Thompson: H. Schumacker or W. Comaskey
Manitoba Department of Environment and Workplace Safety and Health
Mines Inspection Branch
Provincial Building, 59 Elizabeth Drive
Thompson, Manitoba R8N 1X4
Phone: (204) 778-4411

In special cases where a user requires assistance in locating specific holdings, the Resident Geologist in The Pas will travel to Lynn Lake or Thompson to assist the user.

The master file of drill hole logs, collar locations and assays for non-confidential drill core holdings in the northern libraries is available for inspection at the Mines Branch office in The Pas. Information pertaining to non- confidential drill core stored in the Winnipeg library can be viewed at the Mines Branch-Exploration Services office in Winnipeg.

Viewing, Storage and Sampling Policy

Access to confidential drill core is allowed only with written permission from the company that holds the respective property. This written permission must be presented to the Resident Geologist in The Pas, or the Assessment Geologist in Winnipeg, prior to inspection.

Core boxes placed in a library will be managed by drill core personnel. Library users will not be permitted to remove core from the library premises. Users wishing to examine drill core must be prepared to physically handle the core boxes and return them to the racks. Permission is required to sample core contained in the libraries. Assay results and pulps from these samples must be forwarded to the Resident Geologist or Assessment Geologist if so requested. Quartering of previously sampled core will not be permitted.

ACKNOWLEDGEMENTS

The author wishes to extend thanks to C. Hooge and J. Galante for their assistance with the drill core program this past summer. Gratitude is also extended to D. Meek for constructing the core racks at the Winnipeg library. The office staff in Winnipeg and The Pas are acknowledged for their assistance throughout the year.

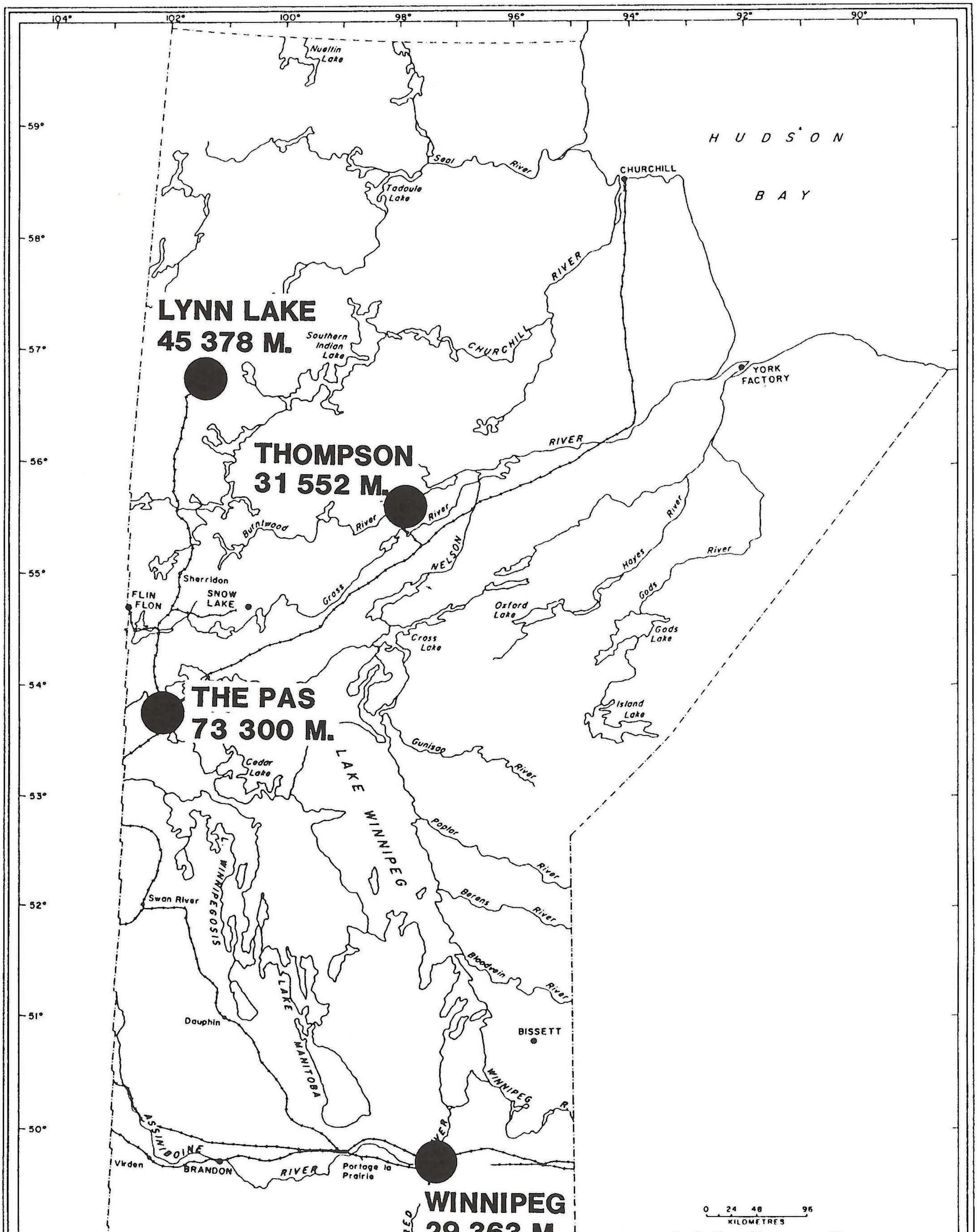

Figure ES-1-3: *Manitoba core library locations and present holdings.*

ES-2 COMPILATION, PROMOTION AND EXPLORATION SERVICES (MDA PROJECT 5.9)

by J.D. Bamburak, L.E. Chackowsky and P. Athayde

Bamburak, J.D., Chackowsky, L.E. and Athayde, P. 1989: Compilation, promotion and exploration services (MDA Project 5.9); **in** Manitoba Energy and Mines, Minerals Division, Report of Field Activities, 1989.

INTRODUCTION

The Exploration Services Section of the Mines Branch has been involved in compilation, promotion and exploration services since 1979. The Mineral Development Agreement (MDA), signed in April 1984 by the Government of Canada and the Manitoba Government, increased staffing and funding and has allowed expansion of these services. This has resulted in: the Bibliography of Manitoba Geology project; the Manitoba Mineral Inventory project; and quality displays, reports and brochures.

COMPILATION

1. Bibliography of Manitoba Geology

The bibliographic compilation project began in April 1985, with the objectives of compiling a continually updated sorted listing and archival library of all geologic literature pertaining to the landmass of Manitoba, and to provide an on-line computerized information storage and retrieval system to allow bibliographic searches by author, year, title, NTS and selected subject keywords.

By January 1989, NTS information had been added to 90% of the references in the database. In addition, subject keywords were appended to about 4000 references acquired from GEOREF and GEOSCAN. This information is used for computer searches and for generating NTS and subject indexes.

Early in 1989, the bibliographic database was transferred from an IBM mainframe to the Section's PC and is maintained using INMAGIC software. This has greatly increased the ease and flexibility of edits, searches and output and has substantially reduced the operating cost. Also, external users will soon be able to search the database and copy references directly into Minerals Division reports.

From September 1988 to August 1989, 132 searches of the database were made for customers and Department staff.

"Bibliography of Manitoba Geology, 1795-1988" (Bibliography Series BMG-1) was released in August 1989 and replaces OF86-1 and OF88-1. This publication contains 7000 references sorted by author/year and is cross-referenced by NTS area. Over 1100 GSC geophysical and geochemical maps are listed in a NTS-sorted table and full reference citations sorted by NTS area appear on a set of microfiche.

The next phase in the project will be to complete the Manitoba Geoscience Archive that contains, at present, about 3100 original copies of Minerals Division and GSC maps and reports. Upon completion, every reference in the database should have a corresponding physical document in the Archives; this will permit the addition of subject keywords to all references in the database. The production of complete NTS/subject indexes and bibliographies will be possible at that time.

2. Manitoba Mineral Inventory

An inventory of platinum-group metal (PGM) occurrences in Manitoba was prepared for release as an open file report to respond to a growing interest in PGM exploration. The 58 PGM occurrences are associated with several nickel, copper, chromite and gold deposits/occurrences. Current PGM exploration projects and potential PGM exploration targets are also documented. Publication is planned for November 1989.

Updating of copper, zinc and nickel mineral inventory cards for the Flin Flon-Snow Lake greenstone belt commenced in September 1988. Completion is planned for January 1990.

From September 1988 to August 1989, more than 100 clients used the Mineral Inventory and Corporation files.

3. Assessment File

During the summer, a student updated, to the end of August, all map mylars in the assessment report index map series. These maps, at a scale of 1:31 680, show former mineral disposition outlines which have assigned to them the corresponding five-digit accession numbers to the assessment files. The mylars are used for reproduction or for overlaying on Mining Recording's claim maps.

Assessment data were used to conduct geophysical interpretation studies of 450 surveys to update the 1978 publication on the Flin Flon-Snow Lake district. This voluminous report (OF87-11) was released January 1989.

Supplements to the "Index to Non-confidential Assessment Reports" (OF86-5) were produced in May and November. During 1988-89, 271 reports of exploration work were received and 212 assessed; 1122 files were microfilmed under a new microfiche project; 70 reports were added to non-confidential files; 679 files were reproduced for the mining sector; 1949 open assessment files were examined by mining industry personnel, 771 by staff, and 301 visits were made by mining company personnel.

4. Index Map Series

The Section reproduces index data plotted on 1:1 000 000 scale mylars. Fourteen mylars show outlines of permits, exploration reservations and airborne geophysical surveys. Six mylars outline map areas of geoscientific publications. Aggregate Resources updated their maps showing aggregate and surficial map coverage.

PROMOTION

1. Monitoring Exploration

During 1988-89, Exploration Services staff spent 74 person-days (excluding the drill core program) in the field and made many contacts with exploration personnel in on-going liaison and monitoring of exploration activity. From April to August 1989, 6 field trips involving 14 person-days were made.

2. Displays

During the past year, the Section has produced displays depicting exploration activity and mining in the province and services provided by the Department. Two major events were: the Annual Meeting with Industry in Winnipeg last November, and the Prospectors and Developers Convention in Toronto in March. Other events were the Manitoba School Career Symposia in Winnipeg (a joint display with The Mining Association of Manitoba), Brandon, Flin Flon and The Pas.

3. Articles

Staff wrote several articles describing the activities of exploration companies in the province, including: "Mineral Exploration in Manitoba 1988" and "Manitoba Exploration Highlights" (revised in November 1988 and March 1989".

4. Committees

Two Section staff have served on the CIM Winnipeg Branch Executive and also on the Mineral Exploration Liaison Committee (MELC) during the year. The Head of the Section served as Manitoba's Co-Secretary to the Mineral Development Agreement Management Committee. One staff member served on the Map Catalog committee.

EXPLORATION SERVICES

1. Publication Distribution

Exploration Services Section is responsible for release notices of new publications; the mailing list of over 700 customers; gift and exchange agreements; preliminary and index maps; Geological Survey of Canada open file reports; various published geophysical maps (aeromagnetic, gradiometer, total field, input, etc.); and for providing consultative services to the Info Centre. New releases for Minerals Division publications and Geological Survey of Canada open files are available from both The Pas Mining Recording and the Winnipeg Information Centre. Coordination is provided by Exploration Services Section.

Open File Reports (OF88-3 and 89-1); Bedrock Geology Compilation Maps for 54E, 63N, 63O and 64H; Aggregate Resources Compilation Maps for 62F, 62G, 62N, 62O, 62P and 63C; Mineral Deposit Report No. 2 and 3 (63K/13) and Mineral Education Series "Gold in Manitoba" (French and English versions), produced under the Canada-Manitoba interim and current Mineral Development Agreements, were distributed following a notification process. (See 'List of Publications Released', this volume.)

The "Canada-Manitoba Mineral Development Agreement 1984-89, Sector 'A' Geoscientific Activities, Progress Report 1988-89" (Open File Report OF89-2) was released in June 1989. This report reviews activities conducted in Manitoba by Manitoba Geological Services Branch, Exploration Services Section of the Mines Branch, and the Geological Survey of Canada during the 12-month period ending March 31, 1989.

In November, the third edition of "The MDA News" was mailed to over 700 addresses on the publications mailing list.

2. Brochures

The following brochures were revised in November 1988 and March 1989:

a. "Staff and Functions of the Geological Services Branch";
b. "Staff and Duties of the Exploration Services Section";
c. "Mining and Exploration Companies in Manitoba"; and
d. "Selected Contractors and Consultants Serving the Exploration Industry in Manitoba."

In March 1989 a revised "Mineral and Exploration Services in Manitoba" brochure was released at the Prospectors and Developers Convention in Toronto.

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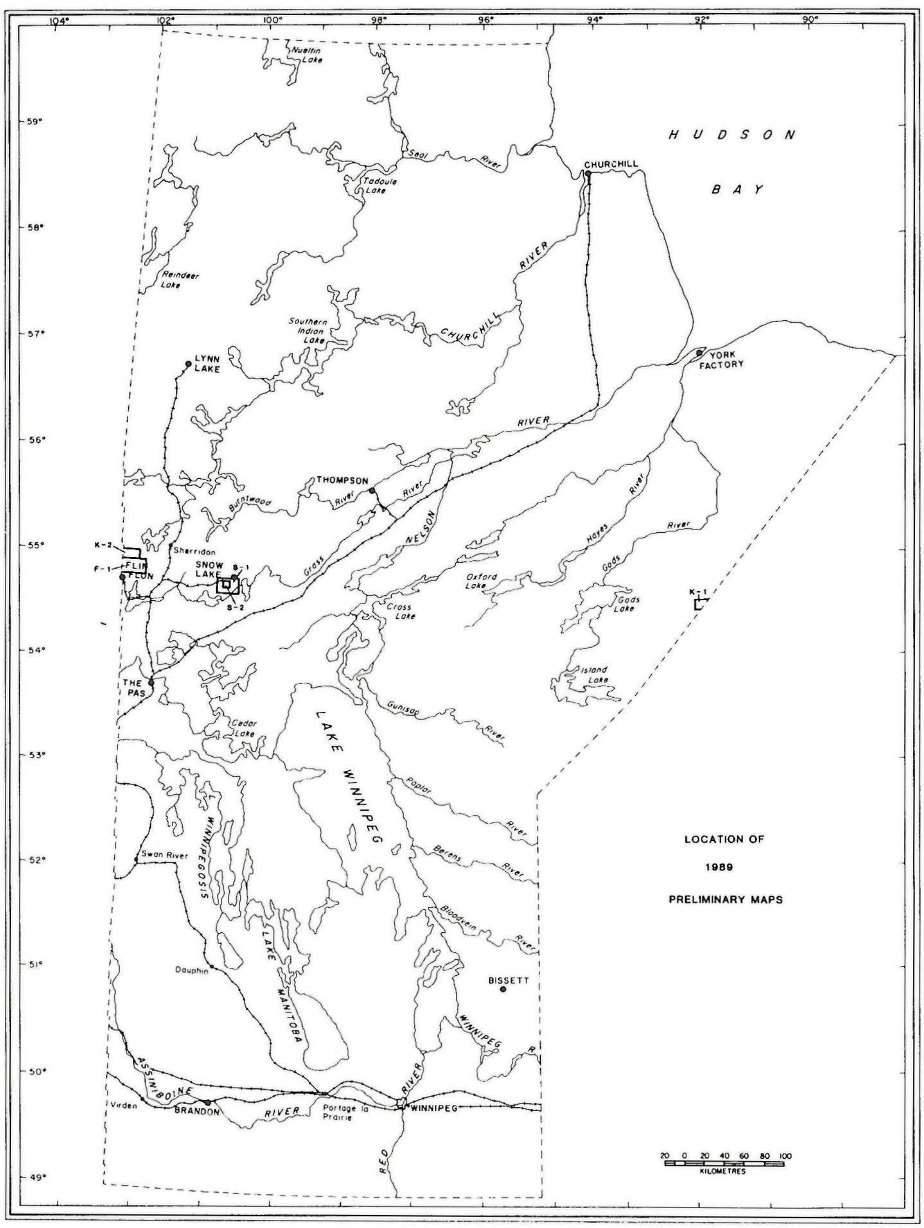

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Director	Dr. W.D. McRitchie	Manitoba
Geological Survey:		
Senior Precambrian Geologist	Dr. W. Weber	Manitoba
Precambrian Geologists	Dr. A.H. Bailes	Snow Lake
	H.D. Cameron	Cross Lake
	M.T. Corkery	Cross Lake-Northern Superior Province, Nelson and Churchill Rivers
	H.P. Gilbert	Tartan Lake, Island Lake, Barrington Lake
	P.G. Lenton	Cross Lake-Kisseynew gneissic belt-granite and pegmatite
	Dr. J.J. Macek	Thompson
	D.C.P. Schledewitz	North of 59°; Kississing Lake
	E.C. Syme	Flin Flon, Athapapuskow Lake
	Dr. H.V. Zwanzig	Churchill Province, Kisseynew belt, Lynn Lake
Mineralogist	C.R. McGregor	Mineralogy, Sub-Phanerozoic Precambrian
Geological Compiler (Atlas)	D. Kowerchuk	1:250 000 Precambrian compilation maps
Phanerozoic Geologist	R.K. Bezys	Southwest Manitoba, Hudson Bay Lowlands, and Interlake
Quaternary Geologist	Dr. E. Nielsen	Manitoba Pleistocene stratigraphy, basal till geochemistry
Mineral Investigations:		
Senior Mineral Deposit Geologist	Dr. G.H. Gale	Manitoba, specifically Flin Flon and Snow Lake
Mineral Deposit Geologists	Dr. P. Theyer	Southeast Manitoba: PGE investigations
	Dr. M.A.F. Fedikow	Snow Lake area and geochemistry
	G. Ostry	File Lake-Sherridon area
	K. Ferreira	Mineral Deposit Geological Assistant
	G. Trembath	Mineral Deposit Geological Assistant L. Norquay
Resident Geologist (Flin Flon)	D. Parbery	Flin Flon - Snow Lake region
Industrial Minerals Geologists	W.R. Gunter	Northern Manitoba
	B.E. Schmidtke	Southern Manitoba
Computerization	G.G Conley	Stratigraphic data files
	D.R. Eccles	Mineral Deposit files
Editorial & Cartographic Services:		
Geological Editor, Section Head	Dr. D.A. Baldwin	

MINES BRANCH

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Resource Management Geologist	C.W. Jones	Aggregate resources management
Geologists	H.D. Groom	Aggregate inventory, R.M. of Pipestone and Albert
	G.L.D. Matile	Aggregate inventory, L.G.D. of Piney
	M.A. Mihychuk	Aggregate inventory, R.M. of Franklin
	R.V. Young	Aggregate inventory, R.M. of Lorne and Argyle
Exploration Services:		
Section Head	W.D. Fogwill	Exploration activity in Manitoba
Assessment Geologist	B. Esposito	Assessment files
Resident Geologist, The Pas	D.E. Prouse	Exploration activity, drill core program
Staff Geophysicist	I.T. Hosain	Regional compilation of assessment data
Mineral Resource Geologist	J.D. Bamburak	Mineral resource information
Mineral Information Geologist	P.D. Leskiw	Publications; information
Computer Systems Geologist	L.E. Chackowsky	Indices to Manitoba geoscience data; bibliography
Mineral Inventory Geologist	P. Athayde	Mineral deposit data